ERDC/CERL TR-07-48

US Army Corps
of Engineers®
Engineer Research and
Development Center

Profiles for High-Priority Species

Focus of the Army Threatened and Endangered Species Research Program

Harold E. Balbach and Elizabeth L. Keane

November 2007

Construction Engineering
Research Laboratory

Army Threatened and Endangered Species Research Program

ERDC/CERL TR-07-48
November 2007

Profiles for High-Priority Species

Focus of the Army Threatened and Endangered Species Research Program

Harold E. Balbach and Elizabeth L. Keane

Construction Engineering Research Laboratory
U.S. Army Engineer Research and Development Center
2902 Newmark Drive
Champaign, IL 61822-1076

Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit 008B36

Abstract: A need arose during the conduct of Threatened and Endangered Species (TES) research for a source of material about the Army's priority TES that would be accessible to (primarily) non-biologist researchers performing various studies on habitat associations using remote sensing, GIS, and other technologies. This is a primer to the characteristics of the species, and why they were of interest to the Army; it also identifies in a preliminary way where the critical gaps were in our knowledge about the TES. This material is intended to be used primarily by research, land management, and training directorate personnel who are not trained biologists, or are not trained with respect to one or more of the species included. The suggested uses include general orientation as to the characteristics and needs of the various species, and awareness of the nature of the potential for Army involvement with them. Although the information presented here is from reliable sources, all references to this document in subsequent reports and publications should be considered secondary, and the original sources should be cited where appropriate. The material may also be provided to contractors who are new to the location or have not worked in the habitats previously.

Contents

Figures

Preface

The material in this report was originally assembled in 2004 and significantly updated in 2006 as part of Work Unit CNN-T011, "Maneuver Disturbance Assessment Applied to Gopher Tortoise," and Work Unit *Maneuver Disturbance Assess Applied to Gopher Tortoises*, "Rangewide GT Conservation," a part of the thrust "Training Lands Management-Characterization, Analysis, and Mitigation," under program element P622720A896, "Base Facilities Environmental Quality." This work was funded by Headquarters, U.S. Army Corps of Engineers. The Technical Monitor was Scott Belfit.

This material was assembled under the guidance of Dr. Harold Balbach, Principal Investigator, U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL), in support of the Army Threatened and Endangered Species Research Program.

At the time of the performance of this work, Steve Hodapp was the TES Program Manager, Alan Anderson was Chief, CEERD-CN-N, and Dr. John T. Bandy was Chief, CEERD-CN. The associated Technical Director was Dr. William D. Severinghaus, CEERD-CV-T. The Director of CERL was Dr. Ilker Adiguzel.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

1 Introduction

Background

A need arose during the conduct of Threatened and Endangered Species (TES) research at the Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) for a source of material about the Army's priority TES that would be accessible to (primarily) non-biologist researchers who were performing various studies on habitat associations using remote sensing, GIS, and other technologies. The initial version of this report was used by several teams for this purpose to help them determine the habitat characteristics that should be incorporated in the land-use modeling so as to be appropriate in locating the highest-likelihood sites for each of the species. In essence this was a primer and beginner's reference to the characteristics of the species and why they were of interest to the Army; it also identified, in a preliminary way, our critical knowledge gaps about the species. This report expands and updates that original internal reference guide, and documents the work done for this purpose.

The basic information in these profiles is drawn from a variety of secondary sources. Large and small sections of appropriate references have been incorporated, merged, abridged, edited, and combined with new material. It is not always possible to separately identify every source in such cases. Considerable relevant material has been derived from the various U.S. Fish and Wildlife Service (USFWS) Recovery Plans, and much basic background material from the NatureServe website. We also acknowledge a very useful summary by Noreen Damude (2001), Texas Parks and Wildlife, describing and contrasting the golden-cheeked warbler and the black-capped vireo, as well as the 2002 ERDC report by Guilfoyle that examines issues related to managing both species near Corps of Engineers project sites in Texas.

What is the Research Requirement?

The following section documents the two endangered species related requirements identified in the Army Environmental Requirements and Technology Assessments (AERTA) process. This process generates user requirements that are used as guidance for environmental research and

development within the Army. Requirements 4.6a and 4.6c relate to the impacts of threatened and endangered species on the military. The background for both of these requirements are the same, however the criteria for basic and applied research differ.[1]

Goals and Objectives

> The Army must continually integrate training and operational requirements, including land availability, with T&E [Threatened and Endangered] species and SOC [species of concern] requirements.
>
> The primary goals are:
>
> • Minimize T&E and SOC related limitations on military training and operations.
>
> • Enhance military training and operations programs.
>
> To accomplish these goals, the following research objectives are required:
>
> • Research and analyze potential direct and indirect impacts of military training (e.g., noise, smokes, maneuvers, excavation, and contaminants) on T&E species and SOC;
>
> • Research and analyze potential direct and indirect impacts of installation operational activities (e.g., installation maintenance, forest management, hunting) on T&E species and SOC;
>
> • Identify T&E species and SOC related mitigation strategies and measures that may be employed to maximize training, as well as other military operational opportunities and requirements;
>
> • Conduct population viability analyses;
>
> • Research and investigate T&E species and SOC in a larger ecosystem context, including interrelationships and impacts of habitat fragmentation. Efforts in habitat fragmentation will be focused on partnering with other federal agencies; efforts for minimizing impacts of encroachment will be focused inside the Army;
>
> • Research and analyze diseases of T&E species;
>
> • Research and analyze invasive-exotic species effects on T&E species;
>
> • Research and analyze genetic viability of fragmented and/or low density populations;
>
> • Research and analyze taxonomy and sub-speciation of T&E species.
>
> Focus should be on ecosystem research, rather than single species research. While substantial focus will remain on prioritized T&E species, attention will also be given to those species that may be listed in the future, with emphasis

[1] U.S. Army Environmental Requirements and Technology Assessments (AERTA), "Environmental Technology Requirements for FY02," June 2002.

given to those species with the greatest potential to affect mission activities. Proactive research for those species may preclude costly constraints or restrictions on future installation training and operations.

Extent of the problem:

Currently, there are 170 T&E species on 94 Army installations. The US Fish and Wildlife Service stated that 800 more species might be added to the national list within the next eight years. Since a large portion of those species will certainly exist on Army installations, the problem will only grow larger, causing even more impacts to mission accomplishment.

Species priority:

The ESA requires the Army to conserve, manage, and even enhance T&E species on lands under its jurisdiction. Nonetheless, potential conflict is greater for some T&E species than others, necessitating T&E species to be ranked and prioritized for research funding. From an Army perspective, some T&E species may be considered relatively more important than others. Criteria used to prioritize species for research efforts related to this Requirement include, but are not necessarily limited to:

- Current or potential effects to the military mission (i.e., potential to impact military readiness, number of acres occupied by species, whether or not critical habitat for the species was designated, etc.)
- Potential of land to support military training
- Number of military installations where species occur
- Cost (to include cost of investigation and research, species management, mission work-arounds)
- Number of other species within the same ecosystem that will benefit from the research
- Potential applicability of investigation and research efforts to other T&E species and SOC
- Potential to provide the most benefit for the military mission with dollars spent on research and development

The current species priorities are the gopher and desert tortoise, red-cockaded woodpecker, black-capped vireo, golden-cheeked warbler, Indiana bat, lesser long-nosed bat, and gray bat. Research that focuses on species groups and adopts an ecosystem or regional approach will be of high importance, as the goal is to derive cost effective, easy methods that can be used on installations nation-wide.

Technology Strategy:

Basic and applied research is the responsibility of the Army Engineer Research and Development Center, which will leverage/integrate/exploit other Army technology; current opportunities include noise, contaminants, and encroachment.

Technology transfer is the responsibility of the Office of the Director of Environmental Programs through the U.S. Army Environmental Center. Technology transfer includes demonstration/validation, fielding, support, and review and transfer of existing technology (information synthesis and transfer), identifying training work-arounds and identification and testing of new tools/techniques. Specific initiatives are partnering with other agencies/organizations, consideration of future contentious T&E species and SOC issues, and consideration of habitats/species of concern.

Policy is the responsibility of the Assistant Chief of Staff for Installation Management, Office of the Director of Environmental Programs, at the direction of the Assistant Secretary of the Army (Environment, Safety, and Occupational Health) and with the assistance of U.S. Army Environmental Center. Current initiatives of T&E species technology policy include minimization of encroachment/land use constraints, management strategies for species on multiple installations, DoD/regional programmatic consultations, conflict resolution teams, and improving collaboration between trainers and natural resources managers.

First Requirement A (4.6a) Reducing Impacts of Threatened and Endangered Species on Military Readiness

Need Description:

There is an urgent need to know the impact of military-unique actions on Threatened and Endangered (T&E) species and Species of Concern (SOC), their habitats, and associated ecosystems to effectively carry out military readiness missions and comply with the legal requirements to conserve the species. The knowledge of the effects of military activities will allow conservation efforts to be directed toward mitigation of real, not speculative, training impacts. Without this knowledge, the Endangered Species Act regulators are forced to hold the Army to the most stringent standards to protect T&E species on Army lands, thus regulatory restrictions are more severe. It is likely that many training restrictions have been imposed due to a lack of knowledge of the effects of military activities on individuals or populations. The focus of this requirement will be on the military impacts of noise, smokes and obscurants, maneuver (including excavation), and environmental contaminants.

There is a need to identify T&E species and SOC related mitigation strategies and measures that may be used to maximize an installation's ability to support the military mission.

There is a need to avoid/manage habitat fragmentation. Habitat fragmentation is recognized to be the single greatest threat to biodiversity globally. Fragmentation includes both loss of habitat and isolation of increasingly smaller parcels of essential habitats. Maneuver training needs to avoid fragmentation effects on T&E species and SOC habitats.

There is a continuing priority requirement to meet Army training and installation operation standards while still conserving T&E species and SOC. The Endangered Species Act, as well as Army Regulation 200-3, prohibits the Army from taking any action that may jeopardize the continued existence of T&E species. Threatened and endangered species requirements and considerations are among the top environmental issues impacting training and testing programs and are a major factor in encroachment. The Senior Readiness Oversight Council has recognized T&E species as one of eight major elements of encroachment. During 2001 and 2002, Congress is investigating T&E species requirements as a major impediment to military training.

Performance Criteria for Basic and Applied Research: A series of planned actions will be implemented to help satisfy the identified Requirement. Species ranking criteria will be developed with advice, input, and concurrence from the Army T&E Species Advisory Group. These actions will require MACOM and installation support. The species rankings may change from year to year, based on the most recent priority values as they relate to Army interaction.

Additional Information: The requirement for protocols for military operations on TES was ranked as conservation priority number 1 in the 1993 requirements prioritization effort and remained as the number 1 requirement in the 1999 requirements five-year review/reprioritization effort.

First Requirement A (4.6c) Maintaining Readiness by Improving Threatened and Endangered Species Monitoring Capabilities

Need Description:

There is an urgent need to have effective Threatened and Endangered (T&E) species and Species of Concern (SOC) survey, inventory, and monitoring protocols. They are essential to retain military mission capabilities by complying with the Endangered Species Act (ESA) and the requirements of ESA regulators. While substantial focus will remain on priority, listed T&E species, attention must be paid to those species that may be listed in the future, with priority

given to those having the greatest potential to affect the Army mission. Prospective research and application of innovative management techniques for those species may avoid costly future restrictions on Army testing and training activities.

Performance Criteria for Basic and Applied Research: A series of planned actions will be implemented to help satisfy the identified requirement. Species ranking criteria will be developed with advice, input, and concurrence from the Army T&E Species Advisory Group. These actions will require MACOM and installation support. The species rankings may change from year to year, based on the most recent priority values as they relate to Army interaction.

Additional Information: This requirement is conservation priority number 2. It was ranked as conservation priority number 2 in the 1993 requirements prioritization effort, in the 1999 five-year review/re-prioritization, and the 2001 Army T&E Species Advisory Group review/re-prioritization efforts. The requirements were slightly revised in 2007, although the principles remain similar.

Objective

The objective of this report is to provide to researchers and others concerned with those threatened and endangered species of highest interest to the Army with a reasonably simple set of information about each of these species and the concerns associated with them. The species are: black-capped vireo, golden-cheeked warbler, gray bat, gopher tortoise, Indiana bat, lesser long-nosed bat, and red-cockaded woodpecker.

Scope

The seven species selected for inclusion here were chosen based on their known or potential likelihood for conflict with the Army mission on the installations where they are found. These seven, plus the desert tortoise, ranked highest in qualitative and quantitative surveys of present and possible training restrictions and/or potential to add significant monitoring or protection burdens. The desert tortoise was omitted here because it was felt that other agencies were performing such extensive study that there would be only small value for the prospective users of this report.

Approach

No original field research has been conducted during the assembly of this information. Rather, a very wide variety of available sources have been accessed, and material taken from them for inclusion here. Varying amounts of original material, including discussions, observations, conclusions, and facts developed personally by the authors have been added and inserted throughout. The material here should be considered as a compilation of existing information rather than as an original work.

Mode of Technology Transfer

The information included in this report is one portion of the materials prepared by the Engineer Research and Development Center (ERDC) to assist installation natural resources managers and TES program managers, as well as researchers who are not primarily biologists and/or are not familiar with the problems and requirements of one or more of the species included. The specific data presented are intended to be used as general background in the preparation of biological assessments related to planned Army actions where these species are present. The data may also be used as background for endangered species management plans (ESMPs), integrated natural resources management plans (INRMPs), and in the preparation of ecological risk assessments involving training and other land-disturbing activities where these species are present. It is recommended, however, that local, current data and information be acquired in all cases to supplement and/or verify the statements and recommendations contained in this report. This report will be made accessible through the World Wide Web (WWW) at URL http://www.cecer.army.mil.

2 Species Profile for the Black-Capped Vireo

Black-capped Vireo[1]
Vireo atricapillus

Status

Endangered (52 FR 37423-October 6, 1987) without critical habitat. A notice announcing a five-year review of this species was published in 2005 (70 FR 5460, February 2, 2005).

Description

The black-capped vireo is a small songbird approximately 11 cm in length and 10 grams in weight. The sexes are dimorphic. On the adult male, the crown and upper half of the head is black and sharply demarcated. Black extends farther posterior on older males. The back is olive-green and undersides are white with olive-yellow flanks. Wings have olive-yellow-black plumage colors with two light yellowish wing bars. The adult female is similar in color except for a gray crown, often with some black around the white eye mask, and under parts washed with greenish yellow. Adults have a red to reddish-brown iris. Immature birds are browner above and buffy below (Grzybowski 1995).

Population

The known population consists of populations in Oklahoma, Texas, and Mexico. Grzybowski (1995) in his review of the species, cites data collected in 1990 to 1994 and reports three populations in Oklahoma; one had 20 to 30+ adults, a second where 150 breeding females were documented, and a third that consisted of a very small group of birds. He also cites reports of <150 adults in the Austin area of Texas (in 1989) and 450 adults in Kerr County, Texas (in 1990). Other sites in Texas contributed a count of 357 males at Fort Hood in 1997 (The Nature Conservancy 1998) and 12 males at Camp Bullis/Fort Sam Houston in 1997 (Weinberg 1998). The estimated

[1] NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer . (Accessed: June 16, 2006). Fish and Wildlife Service. 2006. Black-capped Vireo. Species profile. http://www.fws.gov/southwest/refuges/wichitamountains/vireo.html (Accessed: June 16, 2006).

population in Mexico is described in Benson and Benson (1990) and was based on 28 confirmed birds, which the authors extrapolated out to an estimate of 3,139 to 9,463 pairs. See Scott and Garton (1991) and Benson and Benson (1991) for comments and details regarding the methods for the estimate.

Distribution

Breeding Range: The breeding range of the black-capped vireo formerly stretched from south-central Kansas through central Oklahoma and central Texas into central Coahuila, Mexico, and possibly Nuevo Leon and Tamaulipas (Graber 1961, American Ornithologists Union 1983). The northern extent of the range has contracted significantly over the past half-century (Grzybowski 1995, Grzybowski et al. 1986). The species has not been observed in Kansas since the late 1950s (Tordoff 1956, Graber 1961) and reaches its northern limit in Blaine County, Oklahoma (Grzybowski et al. 1986). The vireo appears to be gravely endangered in Oklahoma (Grzybowski et al. 1986, Grzybowski 1989a,b, Ratzlaff 1987) and is declining in many areas of Texas (Grzybowski 1995, USFWS 1991). Black-capped vireos have been reported in at least 40 counties in Texas (Beardmore and Hatfield 1995).

Present: The species breeds from central Oklahoma south through the Edward's Plateau, and Big Bend National Park, Texas, to central Coahuila, Mexico (in blue on Figure 2-1). Larger colonies are found on Fort Hood Military Reservation, and Devil's River and Kickapoo Caverns State Natural areas. The birds winter in Mexico, with most recent records from Durango, Sinaloa, Nayarit, and Jalisco. Also a few wintering reports from Guerrero, Oaxaca, and southern Sonora (orange on Figure 2-1).

Habitat

The birds' preferred habitat consists of scattered trees and numerous dense clumps of shrubs growing to ground level, interspersed with open areas of bare ground, rock, grasses or forbs. Foliage that extends to ground level is the most important requirement for nesting. Most nests are located between 0.4 and 1.24 meters above ground level and are well-screened by foliage. Plant species commonly used as nest substrate are evergreen sumac and shin oak. Black-capped vireo territories can be located on steep slopes, such as heads of ravines or along the sides of arroyos. On such areas, the shallow soils slow succession, and the microclimates provided by

the rugged terrain perpetuate clumping of vegetation, thus sustaining an area suitable for the vireo. On level terrain, vireo habitat tends to change through succession, from prairie grass to oak-juniper woodlands. Black-capped vireo habitat in level areas was maintained by wildfires that kept the vegetation in an early successional stage. Total cover has been found to range from 17 to 88 percent. In west Texas, the vireo occurs in more stable xeric shrub associations consisting of littleleaf ash, mountain laurel, evergreen sumac, cacti, century plant, sotol, ocotillo, and beard grass, and is located primarily along steep canyons.

Figure 2-1. Distribution map of the black-capped vireo.

Habitat Comments: The bird prefers dense low thickets and oak scrub, mostly on rocky hillsides. It nests in areas with clumps of woody vegetation separated by bare ground, rocks, and/or herbaceous vegetation (USFWS 1987), often in areas with little *Juniperus*.

In Texas and Oklahoma, nesting territories had relatively high densities of deciduous vegetation (primarily oaks) close to the ground and occurred where variation in relative density measures of woody vegetation was highest (Grzybowski et al. 1994). Birds avoided higher juniper densities on the Lampasas Cut Plains and more open areas on the Edwards Plateau (Grzybowski et al. 1994). Favorable breeding habitat has 35 to 55 percent dispersed scrub cover (primarily deciduous) in spatially heterogeneous

configurations, with (in most areas) juniper cover well below 10 percent; however, in the Edwards Plateau region and areas to the southwest, junipers may contribute important cover. See Grzybowski et al. (1994) for further details.

In Mexico, the vireo commonly occurs in dense thickets with few spaces between clumps of vegetation (Benson and Benson 1990). Habitat is naturally maintained by wildfires and grazing animals, which keep vegetation in early successional stage (Matthews and Moseley 1990). Its winter habitat preferences are not well-known, though the birds occur also in semi-arid tropical scrub (AOU 1983) and appear to be less specific than in summer (Collar et al. 1992).

The black-capped vireo nests in twig forks of small trees or shrubs, or in a tangle of shrubby growth, usually 0.4-1.3 m above ground; foliage that extends to ground level is important. It often nests in *Quercus* or *Rhus virens*, also other woody plants (USFWS 1987). Males tend to return to their former breeding territory, often selecting clumped vegetation on steep ravine slopes in rugged terrain (Ehrlich et al. 1992).

Habitat Associates: The black-capped vireo co-exists with a wide variety of other species within its habitat. The particular composition of associated species differs somewhat geographically (Graber 1961).

Competition: Territories of the black-capped vireo sometimes overlap with that of the white-eyed vireo or Bell's vireo. No direct competition with other species was observed by Graber (1961).

Threats and Reasons for Decline

Major threats to the continued existence of the black-capped vireo include (1) loss of habitat due to urban development, excessive rangeland improvement, grazing by sheep, goats, and exotic herbivores, and natural succession including juniper invasion; and (2) cowbird brood parasitism (Grzybowski 1995, Shull 1986, Ratzlaff 1987). The black-capped vireo recovery plan (USFWS 1991) and the 1995 Population Viability and Habitat Analysis (PVHA) Workshop Report (USFWS 1996) document regional threats to survival.

Other Information

Breeds: The breeding grounds for this bird are in south-central Kansas (formerly), south through central Oklahoma (two locations, only one of which [Wichita Mountains] has substantial numbers) and central and western Texas (see map in Grzybowski 1991a) to central Coahuila. Formerly there were outlying, possibly temporary, colonies in Nuevo Leon and Tamaulipas, Mexico. The present range includes Blaine County, Oklahoma, south through Dallas, the Edwards Plateau, and Big Bend National Park, Texas, and to the Sierra Madera in central Coahuila (Matthews and Moseley 1990). The black-capped vireo winters in southern Sonora, Sinaloa, and western Durango south to Guerrero and Oaxaca (mostly in Sinaloa and Nayarit) south to Jalisco and perhaps sparingly to Guerrero according to Grzybowski (1991d).

Migration: The black-capped vireo is migratory and is known to winter along the western coast of Mexico from Sonora to Oaxaca (Graber 1961). Although extensive winter surveys have not been done, most observations have been recorded in Sinaloa and Nayarit (Grzybowski 1995). Vireos first arrive on Texas breeding areas during late March to mid-April and in Oklahoma during mid-April to early May (USFWS 1991). Fall migration takes place during August and September. Graber (1961) reports that young birds leave first, followed by adult females, and then adult males.

Ongoing recovery projects in Texas and Oklahoma include intensive cowbird trapping, and nesting ecology and population dynamics studies. An increase in young produced/pair/year has been documented with cowbird removal. Breeding season starts about March 25 and ends about August 31 in Texas. Breeding season differs somewhat in Oklahoma. In 1991, the breeding population in Texas was estimated at about 620 pairs.

Army Installations Concerned

The following installations reported the black-capped vireo was found on site in the 2000 survey, the latest data available: Camp Barkeley, TX; Fort Hood, TX; Camp Bullis, TX; Fort Sam Houston, TX; and Fort Sill, OK.

Recovery Plan for the Black-capped Vireo

U.S. Fish and Wildlife Service, 1991[2]

Current Species Status: This species is listed as endangered. It has undergone substantial range reduction in Kansas, Oklahoma, and Texas. It is extirpated in Kansas, and the Oklahoma population is below 300 birds. Declines have also been documented over much of the species' range in Texas. Its status is uncertain in Coahuila, Mexico.

Habitat Requirements and Limiting Factors: The black-capped vireo occurs in mixed deciduous/evergreen shrubland. Breeding vireos use shrubby growth of irregular height and distribution with spaces between the small thickets and clumps and with vegetative cover extending to ground level. Habitat losses are occurring through development, overbrowsing, and suppression and alteration of natural disturbance regimes. Cowbird nest parasitism has been drastically reducing vireo reproduction in many areas.

Two-hundred eighty adults were found at 33 Texas sites in 1985; 44 to 51 adults at 3 sites in Oklahoma in 1986. As of the 1980s, two of the three main breeding areas in Oklahoma supported less than 10 pairs; the third supported about 300 individuals (Collar et al. 1992). The breeding population in Texas in the 1980s was about 620 pairs (Collar et al. 1992). The total U.S. population in the early 1990s was about 250 to 500 individuals according to Ehrlich et al. (1992). The total population was estimated at fewer than 1000 breeding pairs in 1989. However, the population in northern Coahuila in 1989 was estimated conservatively at 3,139 to 9,463 breeding pairs (Benson and Benson 1990).

Recovery Objective: Downlisting.

Recovery Criteria: All existing populations are to be protected and stabilized; and at least one viable breeding population (of at least 500 to 1,000 breeding pairs each) should exist in each of six regions, including one in Oklahoma, one in Mexico, and four in Texas; and sufficient and sustainable area should exist to support the birds when they are on their winter range; and all of the previously mentioned criteria should have been

[2] U.S. Fish and Wildlife Service, Black-Capped Vireo Recovery Plan (Washington, D.C.: Government Printing Office, 1991), 45.

maintained for at least 5 consecutive years and assurance should exist that they will continue to be maintained. Threats from habitat loss, cowbird parasitism, and other factors will need to be resolved.

Actions Needed:

- Additional surveys.
- Clarify population size, area requirements, and location needs for viable populations.
- Maintain viable populations in target areas.
- Conduct research on species' biology, habitat needs and management, threats, and winter range.
- Eliminate threats from cowbird nest parasitism, habitat deterioration, and other agents.
- Develop and conduct a program for monitoring the vireo's status.

Military Installation Context: We note that all the above actions have been actively pursued by the Army at Fort Hood, Camp Bullis, and other locations in Texas and Oklahoma where the species is found.

Reasons for Listing:

Population decline: The black-capped vireo has undergone a substantial reduction in range since documentable times. Fragmentation and reduction of numbers within the current range has also occurred. The black-capped vireo no longer nests in Kansas. Its range has been reduced to three locales in Oklahoma, and it will likely occur in only two, possibly one, of those shortly; it is secure in none of these areas. This vireo is likely extirpated from much of its former range in north-central Texas and soon may become extirpated on the southeastern edge of the Edwards Plateau (i.e., Bexar, Comal, and adjacent counties) These areas with extirpated or declining populations comprise over 50 percent of the historical range.

Reproductive success: Reproductive success is low at sites investigated in Oklahoma and on the central Edwards Plateau. No young were produced by the vireos monitored in Caddo and Canadian counties, Oklahoma, from 1984 to 1989 where cowbird parasitism was not controlled (Grzybowski 1985a, 1989a,b). Adult numbers were already very low in 1985 (13), and only one male could be found in 1990 (Grzybowski 1990a). No young were produced during 2 of 3 years of monitoring in Blame County, Oklahoma, without human intervention (in the form of removal of cowbirds and/or their eggs). In the third year, 8 to 10 young were produced by 4 females

(Grzybowski 1989b). Reproductive success without human intervention in the Wichita Mountains averaged 0.94 young/female from 1986 through 1990 (Grzybowski 1990b). At the Kerr Wildlife Management Area, Texas, reproductive success without human intervention was 0.66 young/female from 1985 through 1988 (Grzybowski 1990a,b).

Low recruitment (number of young entering the breeding population): Estimates of reproductive success and survivorship are subject to biases, including the potential depressing influence of investigators on reproductive success, difficulty in counting young already fledged, and the inability to detect individual banded birds dispersing off study sites (which will lower estimates of survivorship).

In west-central Oklahoma and the Austin, Texas, area, vireo numbers are seriously declining. On Fort Hood Military Reservation (MR), the estimate was also low. For the Wichita Mountains and Kerr County, where natural reproductive success was about one young/female/year, recruitment is still below that expected for a stable population. Only in Val Verde, Kinney, and Edwards Counties did the estimated pre-second year (pSY) achieve that expected for a stable population. Thus, in data collected from a substantial portion of the range, recruitment did not achieve levels expected for a stable population and is generally consistent with conclusions from reproductive success. However, according to Tazik (1991a,b), on Fort Hood more second-year males were located during 1991, in conjunction with surveys for the golden-cheeked warbler. They were found in areas not ordinarily searched in the past for vireos.

Nest parasitism by cowbirds: In recent times, three cowbird (*Molothrus* spp.) species have shown dramatic increases in numbers and range across this hemisphere (Friedmann 1929, Grinnel and Miller 1944, Mayfield 1965, Post and Wiley 1977a, Dolbeer and Stehn 1979, Brittingham and Temple 1983). Breeding bird surveys conducted by the U.S. Fish and Wildlife Service show that brown-headed cowbirds are more abundant in mid-continent areas (which includes the southern Great Plains) and their numbers are increasing. A number of factors may be involved in the increase in cowbirds. These factors range from an increase in suitable cowbird habitat beginning in colonial times with the opening of the forests (Friedmann 1929, Mayfield 1965) to increased urban development, grazing impacts, and a speculated higher overwinter survival caused by favorable habitat conditions during winter due to rice fields, feed lots, etc. (Britting-

ham and Temple 1983). Whatever the causes, the impacts are being felt by the black-capped vireo and other species such as the Kirtland's warbler (*Dendroica kirtlandi*, Mayfield 1960, Walkinshaw 1983), least Bell's vireo (Goldwasser 1981; Goldwasser et al. 1980; Franzreb 1989), and yellow-shouldered blackbird (*Agelaius xanthomus,* Post and Wiley 1977b).

Early this century, Bunker (1910) commented that black-capped vireos were frequent victims of nest parasitism by brown-headed cowbirds. J.W. Graber (1957), the first to quantify cowbird impacts on the vireo, found that 50 percent of the eggs, (49 percent of the nests; Graber unpubl. data) were affected by cowbird parasitism in Caddo County, Oklahoma, during the mid-1950s. In the 1980s, more than 70 percent of the nests were parasitized across the range examined. At some localities, in some years, parasitism exceeded 90 percent for fairly large samples (Grzybowski 1990a, b); Tazik and Cornelius 1993. This parasitism has been credited for the alarmingly low annual pair success, which has been much less than one young per pair at a number of sites studied in Texas and less than 0.5 young per pair for areas in Oklahoma (Grzybowski 1985b, 1988, 1989a,b, 1990b). The bronzed cowbird has been recorded only once as a parasite in black-capped vireo nests. However, the first shiny cowbirds detected in Texas and Oklahoma appeared in black-capped vireo nesting areas (Grzybowski and Fazio 1991, Lasley and Sexton 1990).

Nest parasitism shows annual variation. Even at sites with high parasitism, parasitism may drop to 50 or 60 percent some years (Grzybowski 1990a,b). This variation may allow for higher production in those years, but it may simply equal the rates of decline in vireo populations. Average annual parasitism is still relatively high, and average reproductive success is still less than that needed to maintain populations in many areas, even assuming optimistic survival rates (Grzybowski 1986, Pease and Gingerich 1998). Cowbirds have been noted to lay from 1 to 4 eggs in vireo nests (Grzybowski 1985a, Tazik and Cornelius 1993). One egg is optimal for cowbird survival because the vireo nests (with few exceptions) are too small to accommodate more than one cowbird beyond age 5 days. Where cowbirds are more numerous, however, the number of nests with multiple cowbird eggs in them increases. Cowbird egg incubation time is 10-12 days, usually 11. Time from hatching to fledging is 10 to 11 days. Cowbird young leave their foster parents 14 to 20 days after fledging (Friedmann 1929).

Cowbirds interfere with vireo nesting in one or more of the following ways:

a) Cowbirds lay an egg in the vireo nest. Because incubation time of the cowbird egg is 4 to 5 days less than that of the vireo, the cowbird young is much larger than the vireo young (if the vireo eggs even hatch). Thus, no vireo young can be produced from a parasitized nest unless the cowbird egg is infertile or laid late in the vireo's incubation period.
b) Cowbirds often remove a vireo egg for every cowbird egg they lay.
c) Vireos may attempt to complete a full clutch of four vireo eggs (although laying more than four) despite the presence of a cowbird egg(s). The remaining vireo eggs may be spaced farther apart in time than in a normal egglaying sequence. If cowbird eggs are infertile, or are removed, the most recently laid vireo eggs may not be incubated long enough to hatch, thus reducing brood size (Grzybowski pers. obs.).
d) Cowbirds may poke tiny holes in the vireo eggs they do not remove (intentionally, or in attempts to remove them).

The black-capped vireo's small size precludes several options, including physically deterring the cowbirds or ejecting cowbird eggs.

Natural defense from parasitism is limited and includes the following:

a) Vireos may abandon parasitized nests. Tazik et al. 1989 recorded 37 percent of nests were abandoned and credited 28 prcent to parasitism. Abandoning nests may reduce the impact of parasitism, as a portion of the renesting will be unparasitized.
b) Vireos may bury the cowbird egg with nesting material. This has been observed on several occasions and can occur when the cowbird egg is laid before completion of the nest lining (Grzybowski pers. obs, Rothstein 1990).
c) Nest concealment may offer some protection from parasitism. However, cowbirds often watch adults building nests, and many vireos build in pendulant nests, which tend to be more visible than nests of other species. The impact of cowbirds on the southwestern vireo populations needs further investigation to evaluate the ability of vireo populations in these areas to maintain their numbers with cowbird nest parasitism without human intervention. Trapping is not recommended until such background data are collected over a minimum of 2 years (unless cowbird parasitism is demonstrated to

be very extreme in the first year). This step may significantly reduce costs of recovery if parasitism is not a serious threat in a given area.

The following are methods that have been used for local cowbird removal:

a) Use of cowbird decoy traps (Mensing 2004; Siegle 2004) at or near breeding sites. This method has been the most commonly employed and has generated some level of success at all sites used. Some refinements in trap use may need attention, both from the perspective of their design (to prevent escapes and predation) and perhaps more importantly in their placement in ways that substantially improve their influence zones. Information from current and past and proposed trapping efforts should be used to address this issue.
b) Trapping at cowbird feeding sites may help enhance influence zones of the traps, or reduce local numbers of female cowbirds, thus reducing their overall impact. Significantly more females have been captured near cattle or buffalo than in traps away from these animals (Grzybowski 1990b). Rotational grazing at the Kerr Wildlife Management Area placed cattle adjacent to vireo nesting areas at the beginning of the nesting season (Grzybowski 1991c). In both of these studies, parasitism was substantially reduced, and vireo reproductive success enhanced. Where cattle are present in the landscape near vireo breeding areas, this trap placement may be a useful strategy. It should be noted that Fort Hood makes extensive use of cowbird traps as a part of its endangered species management program.
c) Shooting at breeding sites; Tazik and Cornelius (1993) have demonstrated some success using this method with the aid of cowbird recordings, which attract cowbirds to the gunmen. (Note: This technique may be disruptive to nesting vireos.)

Direct habitat destruction: Conversion of potential vireo habitat to urban and suburban development may threaten the vireo in some areas. Such development has been a factor in western Travis County, Texas, where road construction and subdivision development have impacted or threatened vireo nesting areas (Espey, Huston and Associates 1988, DLS Associates 1989). A significant “colony” on the Davenport Ranch has declined dramatically from 27 pairs in 1985 to 4 pairs in 1990 (Grzybowski 1990b). This site is now surrounded by suburban development and has become isolated from other vireo breeding areas by 10 km. The problem may be further compounded by the addition of several predators (i.e., house cats

and dogs) and an increase in numbers of other predators (e.g., raccoons, skunks, jays, squirrels, etc.). This form of development may have been or may currently be impacting vireos in Dallas, Bexar, and Kerr counties, but it has not been studied in these areas.

Range management that removes low woody vegetation is widespread across the vireo's range, but may be most extensive on the Edwards Plateau (Marshall et al. 1985). This process destroys vireo habitat and can substantially impair recovery of these areas; however, in some instances it provides a disturbance regime that creates vireo habitat. Many areas cleared by ranchers are then grazed by cattle, goats, and sheep, and thus restrained from again becoming vireo habitat. However, some sites bulldozed in Kerr County and on the Fort Hood MR have grown into vireo habitat.

Overbrowsing, particularly by goats (but also deer and some exotic animals) can remove vegetation in the lower height zones required by vireos for nesting. The substantial Angora goat enterprise and proliferation of browsing exotic game animals on the Edwards Plateau have removed large areas of vireo habitat (Marshall et al. 1985). If the root structures of deciduous plants can still support growth, the results of overbrowsing may he reversed if the animals are removed. Regrowth of browsed vegetation may develop into vireo habitat, as has occurred on the South Fork Ranch in Kerr County (Grzybowski pers.obs.).

Habitat loss or deterioration through control of natural processes: Some areas of black-capped vireo habitat appear to be relatively stable, but in other areas vireos occupy a successional habitat that passes through a period of suitability. Control of natural processes may prevent the creation and maintenance of vireo habitat in certain areas. The expectation under natural conditions is that a mosaic of habitats exists with differing histories of disturbance and thus a certain proportion of land will likely be in the successional stage suitable for vireos.

Fire Suppression: Fire was likely responsible for maintaining or periodically returning some areas to vireo habitat in the past. Fires still occur, but are suppressed in many areas, so the probability of an area being in the appropriate successional stage is probably lower than in the past. Lands in public ownership may not be large enough (or may be in multiple use settings) to depend on random disturbance events, such as fire, to maintain

adequate amounts of vireo habitat. Habitat deterioration due to control of natural processes may result in (a) decreasing amounts of suitable habitat as the habitat matures (b) increased fragmentation of what may historically have been large patches or series of patches of suitable habitat, (c) increasing isolation between vireos in occupied patches, (d) decreasing probabilities of young vireos dispersing successfully between these patches, (e) increased potential for nest predators such as jays and squirrels from the surrounding, more mature habitat to invade and impact nesting success of black-capped vireos in the remaining smaller patches, and (f) increased potential for extinction as probabilities for successful dispersal and reproductive success decline.

The circumstances in this fire suppression scenario appear relevant to much of the range from Oklahoma to the southeastern edge of the Edwards Plateau. These conditions may currently exist in most of west-central and central Oklahoma outside of the Wichita Mountains. A number of formerly occupied sites have matured substantially (to heights over 40 feet), and west-central and central Oklahoma now contain significant numbers of junipers. More suitable patches were observed than occupied, but these patches were often relatively small (<50 ha) and isolated by distances measured in kilometers from each other (Grzybowski 1986, pers. obs.). The trend of this influence in Texas is uncertain, but may be impacting significant areas of the Lampasas Cut Plains and Balcones Canyon lands as represented in southern Dallas County, western Travis County, and Bexar and Uvalde counties. Additional research is needed to determine which areas of vireo habitat are relatively stable and which will need periodic disturbance to maintain.

Indirect effects of land use: Some land uses or habitat modifications that do not necessarily directly impact vireo habitat may indirectly impact vireos. For example, in a broad sense, the threat of cowbird nest parasitism results from changes in the habitat that increase cowbird abundances in vireo nesting areas. The cause(s) of these increases can be local, as in increasing suitability of habitat for cowbirds in or adjacent to suitable vireo habitat, and/or it can be remote, as in increasing suitability or availability of cowbird wintering habitat enhancing overwinter survival and thus increasing cowbird numbers. Land uses may also increase suitable environments for certain predators (i.e., raccoons, skunks, house cats, jays).

Increased effects from predators and nest parasites are sometimes attributed to "edge effects." Patch size is sometimes used to evaluate edge effects. Studies have indicated that both cowbird nest parasitism and nest predation on open-cup nesting passerines decreases with distance from edge (Gates and Gysel 1978, Brittingham and Temple 1983, Andren and Angelstam 1988). A few studies, however, have indicated that the dispersal potential of cowbirds is high (Rothstein 1984), and that parasitism rates may be more species-specific and not as closely linked to edge as other studies indicate. However, edge effects can still occur as specified below.

Cattle in or near vireo habitats can attract cowbirds. On Fort Hood MR, where cattle numbers were over 3,500 animal units during 1987 and 1988, parasitism rates were 90 percent (even with cowbird trapping [Tazik 1991a]). A reduction in cattle numbers on Fort Hood to 1,500 to 2,000 during 1989 and 1990 resulted in a decrease in parasitism to 60 to 65 percent and a dramatic increase in vireo production (Tazik 1991b). However, cattle have been used effectively to significantly increase cowbird capture on the Kerr WMA (Grzybowski 1990b). Where cowbirds are not being removed however, cattle grazing in or near vireo nesting areas may pose a substantial local threat to vireo nesting success. Cattle may also create disturbances if concentrated in vireo nesting areas at the beginning of the nesting period and may cause vireos to abandon the site. Data supporting this contention are limited and subjective.

Predator species such as scrubjays (*Aphelocoma coerulescens*), squirrels, raccoons, and skunks may increase vireo nest predation where food sources for these species (which are often omnivorous) allow their populations to be maintained at artificially high levels. This may be a particular problem where urbanization is occurring. In urban settings, these predators have had a demonstrated influence (Wilcove 1985). The longer incubation time in vireos may make them more sensitive than other passerines to increases in predator numbers. Thus, in some situations, these predators may need to be controlled. Very few nests were predated by mammals. However, as the incidence of parasitism declines, predation may become limiting to production.

Fire ants may create local problems. They tend to invade habitats along corridors of disturbance. Fire ants may have caused vireos to abandon their nests and eggs on a few territories in Travis County. They may be a local problem in other urbanized areas, but have not been noted as a gen-

eral problem rangewide. According to Tazik (1991a) few, if any, problems have been observed on Fort Hood.

Direct human disturbances: Human disturbance near and in nesting areas during the breeding season, particularly at the onset, may alter vireo behavior and/or cause vireos to abandon nests or territories. Use of taped songs may also have adverse effects (Marshall et al. 1985). Excessive use of tapes may have adversely affected the birds' behavior in some areas.

Pesticides: Pesticides, particularly systemics, may be a problem on vireo breeding and wintering areas. These wintering areas are in Mexico, so monitoring and management is extremely difficult, and actual data are not available.

Military Installation Context: As noted in several places above, each of the historic and ongoing threats is, or was, present to some degree on military installations within the bird's range. That said, the Army, especially Fort Hood, has invested large sums into development of programs designed to mitigate or moderate these effects.

Conservation Plan from Fort Hood, TX (2003)

Conservation Actions: Black-capped Vireo[3]

Objective 1: Maintain sufficient habitat to support a minimum carrying capacity of 1,000 singing males.

Population viability analyses indicate that a habitat carrying capacity lower than that necessary to support a maximum of 1,000 singing males of black-capped vireos greatly increases the probability of extinction (Hayden et al. 2001a). Increasing carrying capacities above 1,000 singing males does not significantly alter the probability of extinction. Carrying capacity represents the maximum potential of the habitat to support singing males. Carrying capacity does not necessarily reflect the number of singing males normally expected to occur. A population carrying capacity goal in excess of 1,000 singing males would not significantly lower extinction probability or significantly increase expected number of individuals. A population car-

[3] Hayden, T. J., J.D. Cornelius, and P.A. Guertin. Endangered Species Management Plan for Fort Hood, TX. Technical Report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA.

rying capacity goal of 1,000 singing males meets USFWS recovery objectives for this species.

Objective 2: Implement a sustainable incidental take limit for the 5-year term of this ESMP.

The intent of this ESMP is to promote recovery of endangered species on Fort Hood lands while permitting the military maximum flexibility to perform mission essential tasks. Current estimates of available black-capped vireo habitat on Fort Hood exceed population and recovery goals under this ESMP. Implementation of incidental take limits provides flexibility for conducting mission activities that may result in habitat loss. However, this potential habitat loss is limited so as not to jeopardize baseline habitat requirements and to provide an adequate habitat mitigation bank in perpetuity without implementing further restrictive measures on the military mission. Habitat "loss" as defined under this ESMP is any permanent or temporary alteration of currently suitable habitat to the extent that it is unsuitable for occupation by breeding adults.

Objective 3: Maintain sufficient habitat to meet population goal in seral stage suitable for occupation by black-capped vireos.

Typically, vireos on Fort Hood are observed in early successional habitat resulting from burns or mechanical clearing of vegetation in areas with suitable soils and geologic substrate. Currently, 6,967 ha (17,696 ac) have been identified as suitable vireo habitat. Due to the ephemeral nature of habitat in these areas targeted for habitat management, restoration must be implemented to replace areas where vegetation has succeeded beyond the stage preferred by vireos. This objective maintains at least the current level of vireo habitat on Fort Hood.

Objective 4: Maintain parasitism of vireo nests by brown-headed cowbirds below an average of 10 percent annually in non-live-fire training areas during the 5-year term of this ESMP.

Cowbird parasitism reduces reproductive success of black-capped vireos on Fort Hood (Tazik et al. 1992, Hayden and Tazik 2000). Analyses by Tazik (1991b) of the effect of cowbird parasitism on vireo productivity indicate that the incidence of cowbird parasitism must be below 25 percent to maintain stable or increasing vireo populations. A target goal of average

annual parasitism below 10 percent was determined because of the effectiveness of historical control efforts and to be consistent with thresholds established by the USFWS under other agreements. Since 1992, cowbird control efforts have maintained parasitism levels in non-live-fire areas below 10 percent on Fort Hood. Also, USFWS has established a 10 percent parasitism threshold in provisions of a Memorandum of Understanding with Central Texas Cattleman's Association regarding grazing leases on Fort Hood. Maintaining parasitism levels below an average of 10 percent annually will enhance vireo reproductive success on Fort Hood and support achievement of population objectives. Reducing cowbird parasitism is the only management technique currently available to directly affect reproductive success.

Objective 5: Document black-capped vireo population trend and factors affecting population status.

Population change is the base-line measure of conservation success and recovery for the population. This measure is necessary to differentiate between normal annual variability and true trends in populations over time. Evaluation of factors affecting populations allows a determination of population change due to natural or stochastic processes versus change due to human land use practices.

The Vireo-Warbler Conflict

The black-capped vireo and the golden-cheeked warbler share a portion of their range in central Texas. Both are found in areas of mixed shrubs and grassland; however, the vireo is associated, as noted in the introductory sections above, with an early successional stage dominated by scrub oaks, and avoids areas where juniper has developed a denser cover. The warbler, however, is favored by the juniper-dominated habitat. The requirements for the warbler are stated thus: "Golden-cheeked warblers are restricted to mature Ashe juniper stands mixed with other deciduous tree species, particularly oaks...The bark from the Ashe juniper tree is an integral component of the golden-cheek warbler's nest (Guilfoyle 2002)." This ERDC technical note by Guilfoyle describes the problems of managing simultaneously for two species whose habitat requirements inherently conflict. It was directed toward reservoir operations, but is equally applicable to the military installations.

References

References cited in this chapter and recommended sources for more information: largely from NatureServe (2006) and Cavanagh (2000)

Albert, R. 1974. Checklist of the birds of Jim Wells County, Texas. Privately published.

American Ornithologists' Union (AOU), Committee on Classification and Nomenclature. 1983. Check-list of North American Birds. Sixth Edition. American Ornithologists' Union, Allen Press, Inc., Lawrence, Kansas.

Andrén, H., and P. Angelstam. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. Ecology 69: 544–547.

Armstrong, B. 1989. Nongame wildlife investigations: Black-capped Vireo management. Project No. TX W-103-R-19/Job 60. Unpublished report. Texas Parks and Wildlife Department, Austin, Texas, USA. 22 p.

Armstrong, W. E. 1997. Wildlife research and surveys: Black-capped Vireo management. Final report. Project No. 60. Period covered: 1 September 1997. Project No. TX W-125-R-8. Unpublished report, Texas Parks and Wildlife Department, Austin, Texas, USA. 34 p.

Askins, R. A. 2000. Landscape ecology: the key to bird conservation. Pages 229-245 in Restoring North America's birds: lessons from landscape ecology. Yale University Press, New London, Connecticut, USA.

Attwater, H. P. 1892. A list of birds observed in the vicinity of San Antonio, Bexar County, Texas. Auk 9:340-341.

Bailey, F. M. 1902. Handbook of birds of the western United States. Houghton Mifflin & Co., Cambridge, Massachusetts, USA.

Bailey, J. W., and P. R. Fushille. 2000. Monitoring of the Golden-cheeked Warbler - 2000 field season. Travis County Parks and Preserves, project number 0810-00001. November 2000. Travis County Natural Resources, Austin, Texas, USA. 33p {FHL}

Baird, S. F. 1858. Birds. Explorations and surveys for a railroad route from the Mississippi River to the Pacific Coast. War Department, Washington, D.C., USA.

Baird, S. F. 1859. Report of the U.S. and Mexican boundary survey 2(2):12.

Baird, S. F. 1866. Review of American birds, in the museum of the Smithsonian Institution. Smithsonian Miscellaneous Collection.

Baird, S. F., T. M. Brewer, and R. Ridgway. 1905. A history of North American birds. Volume I. Landbirds. Little, Brown and Co., Boston, Massachusetts, USA.

Barber, D. R. 1993. Effects of alternate host densities on brown-headed cowbird parasitism rates in Black-capped Vireos. M.S. Thesis. University of Arkansas, Fayetteville, Arkansas, USA. 43 p.

Barber, D. R., and T. E. Martin. 1997. Influence of alternate host densities on brown-headed cowbird parasitism rates in Black-capped Vireos. Condor 99:595-604.

Barlow, J. C. 1967. Nesting of the Black-capped Vireo in the Chisos Mountains, Texas. Condor 69:605-608.

Barlow, J. C. 1974. Effects of habitat attrition on vireo distribution in the Northern Chihuahuan desert. Pages 591-596 in R. H. Wauer and D. H. Riskind (editors). Transactions of the symposium on the biological resources of the Chihuahuan desert region United States and Mexico. National Park Service Proceedings Transaction Series No. 3. 658 p.

Barlow, J. C., and B. G. Griffin. 1988. Survey of the status of the Black-capped Vireo in Big Bend National Park, Brewster County, Texas for 1988. Unpublished report prepared for Office of Resource Management, Big Bend National Park, Texas, USA.

Barber, D. R. 1993. Effects of alternate host densities on brown-headed cowbird parasitism rates in black-capped vireos. M.S. thesis, Univ. of Arkansas, Fayetteville. ix + 43 pp. [Arkansas Cooperative Fish and Wildlife Research Unit Publ. No. 10]

Barlow, J.C. 1980. Patterns of ecological interactions among migrant and resident vireos on the wintering grounds. Pages 79-107 in A. Keast and E.S. Morton, editors. Migrant birds in the neotropics: ecology, distribution, and conservation. Smithsonian Institution Press, Washington, DC.

Beardmore, C., and J. Hatfield (Compilers and Editors), Draft Black-capped Vireo Population and Habitat Viability Assessment Report (Report of Workshop in Austin, Texas, September 1995).

Benson, R. H., and K. L. P. Benson. 1990. Estimated size of black-capped vireo population in northern Coahuila, Mexico. Condor 92:777-9.

Bent, A.C. 1950. Life histories of North American wagtails, shrikes, vireos, and their allies. U.S. Natl. Mus. Bull. 197. Washington, D.C.

Beckham, C. W. 1888. Observations on the birds of southwestern Texas. Proceedings of the U.S. National Museum 10:633-696.

Benners, G. B. 1887. A collecting trip in Texas. Ornithologist and Oologist 12:49-52.

Benson, R. H., and K. L. P. Benson. 1990. Estimated size of Black-capped Vireo population in northern Coahuila, Mexico. Condor 92:777-779.

Benson, R. H., and K. L. P. Benson. 1991. Reply to Scott and Garton. Condor 93:470-472.

Bent, A. C. 1950. Life histories of North American wagtails, shrikes, vireos, and their allies. Bulletin No. 197. U.S. National Museum, Washington, D.C., USA.

BirdLife International. 2004. Threatened birds of the world 2004. CD ROM. BirdLife International, Cambridge, UK.

Boice, L. P. 1998. Migratory bird conservation at Fort Hood. Endangered Species Bulletin 23(4):24-25.

Bolsinger, J. S., and T. J. Hayden. 1992. Project status report: 1992 field studies of two endangered species (the Black-capped Vireo and the Golden-cheeked Warbler) and the cowbird control program on Fort Hood, Texas. December 1992. Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 79 p.

Bolsinger, J. S., and T. J. Hayden. 1994. Project status report: 1993 field studies of two endangered species (the Black-capped Vireo and the Golden-cheeked Warbler) and the cowbird control program on Fort Hood, Texas. March 1994. Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. Natural Resources Division, U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 53 p.

Brewster, W. 1879. Notes upon the distribution, habits, and nesting of the Black-capped Vireo (Vireo atricapillus). Bulletin of the Nuttall Ornithological Club 4:99-103.

Brittingham, M.C., and S.A. Temple, "Have Cowbirds Caused Forest Songbirds to Decline?" Bioscience, Vol 33 (1983), pp 31-35.

Brown, N. C. 1882. A reconnaissance in southwestern Texas. Bulletin of the Nuttall Ornithological Club 7:33-42.

Buechner, H. K. 1946. Birds of Kerr County, Texas. Transactions of the Kansas Academy of Science 49(3):357-364.

Bunker, C. D. 1910. Habits of the Black-capped Vireo (Vireo atricapillus). Condor 12:70-73.

Campbell, L. 1995. Endangered and Threatened Animals of Texas: Their Life History and Management. Texas Parks and Wildlife Department, Endangered Resources Branch, Austin, Texas. ix + 129 pp.

Campbell, L. 1995. Black-capped Vireo. Pages 29-32 in Endangered and threatened animals of Texas. Texas Parks and Wildlife Department, Austin, Texas, USA.

Campbell, L. 1995. Management guidelines for Black-capped Vireo. Pages 33-35 in Endangered and threatened animals of Texas. Texas Parks and Wildlife Department, Austin, Texas, USA.

Castiaux, N. 1995. Analysis of the Black-capped Vireo habitat at Kickapoo Caverns State Park, Texas using a Geographic Information System. Thesis. Texas A&M University, College Station, Texas, USA. 87 p.

Casto, S. D. 1997. The birds collected at San Antonio by A. L. Heermann. Bulletin of the Texas Ornithological Society 30:2-10.

Casto, S. D., and J. S. Tomer. 1999. Texas bird records of S. G. Woodhouse. Bulletin of the Texas Ornithological Society 32(1)13-25.

Cavanagh, P. M. 2000. Black-capped vireo bibliography. Endangered species monitoring and management at Fort Hood, Texas: 2000 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA.

Clare, M. F. 1991. The Endangered Species Act and habitat conservation in central Texas. Master of Public Affairs report. University of Texas at Austin, Austin, Texas, USA. 119 p.

Collar, N.J., L.P. Gonzaga, N. Krabbe, A. Madrono-Nieto, L.G. Naranjo, T.A. Parker III, and D.C. Wege. 1992. Threatened Birds of the Americas. The ICBP/IUCN Red Data Book. Third Edition. Part 2. Smithsonian Institution Press, Washington, DC. 1150 pp.

Cruickshank, A. D. 1950. Records from Brewster County, Texas. Wilson Bulletin 62:217-219.

Cook, T. L., J. A. Koloszar, and M. D. Goering. 1996. 1995 annual report: behavior and movement of the Brown-headed Cowbird (Molothrus ater) on Fort Hood, Texas. January 1996. The Nature Conservancy, Fort Hood, Texas, USA. 37 p. + 22 figures.

Cooke, W. W. 1909. The migration of vireos. Bird-Lore 11:118-120.

Coues, E. 1879. Note on the black-capped greenlet, Vireo atricapillus of Woodhouse. Bulletin of the Nuttall Ornithological Club 4:193-194.

Craft, K. P. 1998. Management of historical Golden-cheeked Warbler (Dendroica chrysoparia) and Black-capped Vireo (Vireo atricapillus) data at Fort Hood, Texas. Pages 59-72 in Summary of 1997 Research Activities. Texas Conservation Data Center, The Nature Conservancy, Fort Hood, Texas, USA. 314 p.

Craft, R. A. 1998. Delineation of Black-capped Vireo (Vireo atricapillus) and Golden-cheeked Warbler (Dendroica chrysoparia) habitat on Fort Hood, Texas. Pages 53-58 in Summary of 1997 research activities. Texas Conservation Data Center, The Nature Conservancy.

Cruz, A., T.Manolis,andJ.W. Wiley. 1985. The shiny cowbird: A brood parasite expanding its range in the Caribbean region. In: P. A. Buckley et al. (eds.), Neotropical Ornithology. Ornithol. Monogr., Amer. Ornith. Union 36:607-620.

Damude, Noreen. 2001.The Golden-cheeked Warbler and Black-capped Vireo Biology and Natural History, Texas Parks and Wildlife, Austin, TX.

Davis, L. I. 1975. Birds of the Rio Grande Delta Region, an annotated checklist. Privately published.

Deane, R. 1879. Vireo atricapillus in Texas. Bulletin of the Nuttall Ornithological Club 4:58-59.

Deignan, H. G. 1961. Type specimens of birds in the United States National Museum. Bulletin of the U.S. National Museum 221:1-718.

DLS Associates, Inc. 1988. Status Report #2. 1988 Investigations of the Black-capped Vireo population. Austin Outer Parkway (SH 45), Travis Co., Texas. Unpublished report to LAN/HNTB joint venture for State Department of Highways and Public Transportation, Austin, Texas, USA.

DLS Associates, Inc. 1989. Black-capped Vireo monitoring program, Travis County, Texas and vicinity, 1989. Final report. Unpublished report to The Nature Conservancy, San Antonio, Texas, USA.

Dolbeer, R.A. and R. A. Stehn. 1979. Population trends of blackbirds and starlings in North America, 1966-76. U.S. Dep. Inter., Fish and Wildl. Serv., Spec. Sci. Rep., Wildl. No. 214.

Eckrich, G. H., and T. E. Koloszar. 1999. Brown headed cowbird (Molothrus ater) control program on Fort Hood, Texas. Pages 151-176 in Summary of 1998 endangered species monitoring and management activities at Fort Hood, Texas. Fort Hood Project, The Nature Conservancy, Fort Hood, Texas, USA.

Eckrich, G. H., T. E. Koloszar, and M. D. Goering. 1999. Effective landscape management of brown-headed cowbirds at Fort Hood, Texas. Studies in Avian Biology 18:267-274.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1992. Birds in Jeopardy: the Imperiled and Extinct Birds of the United States and Canada, Including Hawaii and Puerto Rico. Stanford University Press, Stanford, California. 259 pp.

Espey, Huston and Assoc. 1988. 1988 report: Steiner Ranch Black-capped Vireo project. Unpublished report to Hughes Interests, Austin, Texas, USA.

Franzreb, K.E. 1989. Ecology and conservation of the endangered least Bell's vireo. U.S. Fish and Wildlife Service, Biol. Rep. 89(1). 17 pp.

Federal Highway Administration. n.d. (1988) Endangered/threatened species, biological assessment, 50 CFR 402.12(c)(1). Proposed construction for RM 620 in west Travis County, Texas. Federal Highway Administration, Austin, Texas, USA.

Fish and Wildlife Service. 2006. Black-capped Vireo. Species profile. http://www.fws.gov/southwest/refuges/wichitamountains/vireo.html (Accessed: June 16, 2006).

Friedmann, H. 1929. The cowbirds: a study in the biology of social parasitism. Charles C. Thomas, Springfield, Illinois.

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Goldwasser, S. 1981. Habitat requirements of the least Bell's vireo. Calif. Dept. of Fish and Game Final Report., Job IV-38.1.

Goldwasser, S., D. Gaines, and S. Wilbur. 1980. The least Bell's vireo in California: a de facto endangered race. Am. Birds 34:742-745.

Goss, N. S. 1885. The Black-capped Vireo and nonpareil in south-western Kansas. Auk 2:274-276.

Graber, J. W. 1957. A bioecological study of the Black-capped Vireo (Vireo atricapillus). Ph.D. Dissertation. University of Oklahoma, Norman, Oklahoma, USA. 216 p.

Graber, J. W. 1961. Distribution, habitat requirements, and life history of the black-capped vireo (VIREO ATRICAPILLUS). Ecological Monographs 31:313-336.

Graham, R. 1915. Birds that nest in Tarrent County, Texas, and notes. Oologist 32:191.

Greenman, T. M. 1995. Postfire characteristics of existing and potential Black-capped Vireo (Vireo atricapillus) nesting habitat on the Wichita Mountains Wildlife Refuge, Oklahoma. M.S. Thesis. Oklahoma State University, Norman, Oklahoma, USA. 40 p.

Griffin, B. G., and J. C. Barlow. 1989. Survey of the status of the Black-capped Vireo in Big Bend National Park, Brewster County, Texas for 1989. Unpublished report to National Park Service, Office of Resource Management, Big Bend National Park, Texas, USA.

Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. Pac. Coast Avifauna No. 27. 608pp.

Grzybowski, J. A. 1985a. Final report: population and nesting ecology of the Black-capped Vireo (Vireo atricapillus). Part II: nesting ecology of the Black-capped Vireo. Unpublished report to U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico, USA.

Grzybowski, J. A. 1985b Final report: population status of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Submitted to the Nongame Program, Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 68 p.

Grzybowski, J. A. 1986. Population and nesting ecology of the Black-capped Vireo (Vireo atricapillus). Interim report. Unpublished report to U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico, USA.

Grzybowski, J. A. 1988. Black-capped Vireo investigations - 1986-1987, Part I: population and nesting ecology. Unpublished report to U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico, USA.

Grzybowski, J. A. 1989a. Black-capped Vireo investigations: population and nesting ecology. Interim report. Unpublished report to U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico, USA.

Grzybowski, J. A. 1989b. Population and nesting ecology of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Final report, Project E-1-3. Unpublished report to Oklahoma Department of Wildlife Conservation, Oklahoma City, Oklahoma, USA. 80 p.

Grzybowski, J. A. 1990a. Population and nesting ecology of the Black-capped Vireo in Texas - 1988-1989. Unpublished report to U.S. Fish and Wildlife Service, Ecological Services, Arlington, Texas, USA.

Grzybowski, J. A. 1990b. Ecology and management of isolated populations of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Final report, section 6, Endangered Species Act, federal aid project E-1-4, April 1, 1989-March 31, 1990. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 20 p.

Grzybowski, J. A. 1991a. Ecology and management of isolated populations of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Federal aid project E-1-5, April 1, 1990-March 31, 1991. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 20 p.

Grzybowski, J. A. 1991b. Ecology and management of isolated populations of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Federal aid project E-1-6, April 1, 1991-March 31, 1992. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 27 p.

Grzybowski, J. A. 1991c. A closer look at the Black-capped Vireo. Birding 23(4):216-219.

Grzybowski, J. A. 1991d. Survivorship, dispersal and population structure of Black-capped Vireos at the Kerr Wildlife Management Area, Texas. Unpublished report to Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas, USA.

Grzybowski, J. A. 1993. Trapping for success: Black-capped Vireo reproductive success, that is. Scissortail 43(4):37.

Grzybowski, J. A. 1995. Black-capped Vireo (Vireo atricapillus). In The Birds of North America, No. 181 (A. Poole and F. Gill, editors). The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA and The American Ornithologists' Union, Washington, D.C., USA. 24 p.

Grzybowski, J. A., R. B. Clapp, and J. T. Marshall, Jr. 1986. History and current population status of the Black-capped Vireo in Oklahoma. American Birds 40(5):1151-1161.

Grzybowski, J. A. & V.W. Fazio, III. 1991. Shiny Cowbird reaches Oklahoma. American Birds 45: 50-52.

Grzybowski, J. A., and D. J. Tazik. 1993. Status and management of the Black-capped Vireo at Fort Sill, OK, 1988-1991. USACERL Technical Report EN-93/06. March 1993. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 28 p. AD-A269 217/6NEQ.

Grzybowski, J. A., D. J. Tazik, and G. D. Schnell. 1994. Regional analysis of Black-capped Vireo breeding habitats. Condor 96:512-544.

Guilfoyle, M. P. (2002). "Black-capped vireo and golden-cheeked warbler populations potentially impacted by USACE reservoir operations," EMRRP Technical Notes Collection (TN EMRRP-SI-28), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp.

Hamilton, T. H. 1962. The habitats of the avifauna of the mesquite plains of Texas. American Midland Naturalist 67:85-105.

Harris, H. H. 1984. Black-capped Vireo in marshy habitat in Oklahoma County, Oklahoma. Bulletin of the Oklahoma Ornithological Society 17(3):23-24.

Harrison, C. 1978. A Field Guide to the Nests, Eggs and Nestlings of North American Birds. Collins, Cleveland, Ohio.

Harrison, H. H. 1979. A field guide to western birds' nests. Houghton Mifflin Company, Boston. 279 pp.

Hayden, T. J., and D. J. Tazik. 1991. Project status report: 1991 field studies of two endangered species (the Black-capped Vireo and the Golden-cheeked Warbler) and the cowbird control program on Fort Hood, Texas. Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 81 p.

Hayden, T.J., D.J. Tazik, R.H. Melton, and J.D. Cornelius. 2000. Cowbird control program on Fort Hood, Texas: Lessons for mitigation of cowbird parasitism on a landscape scale. In, The Ecology and Management of Cowbirds. (T. Cook, s. Robinson, S. Rothstein, S. Sealy, and J. Smith, Eds.) The University of Texas Press. Austin, Texas.

Hayden, Timothy J., John D. Cornelius, Howard J. Weinberg, Leslie L. Jette, Robert H. Melton. 2001a. Endangered Species Management Plan for Fort Hood. Technical Report.ERDC/CERL TR-01-26, ADA387-495, paa. U.S. Army, Corps of Engineers, Construction Engineering Research Laboratory, Champaign, IL.

Hayden, T. J., J.D. Cornelius, and P.A. Guertin. 2001b. Endangered Species Management Plan for Fort Hood, TX. Technical Report Draft FY06-10 Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA.

J. N. M. Smith, T. L. Cook, S. I Rothstein, S. K. Robinson, and S. G. Sealy (editors), Ecology and management of cowbirds and their hosts. Studies in the conservation of North American passerine birds. University of Texas Press, Austin, Texas, USA.

Hubbard, J. P. 1984. The spring migration, March 1 - May 31, 1984, New Mexico. American Birds 38:945-946.

Hunt, J. 1990. Status of Black-capped Vireos on Fort Hood. Preliminary report 1990. Unpublished report. Arkansas Cooperative Research Unit, Department of Zoology, University of Arkansas, Fayetteville, Arkansas, USA. 22 p.

Imhoff, T. A. 1978. The spring migration, March 1 - May 31, Central Southern Region. American Birds 32:1020.

Johnson, N. K., R. M. Zink, and J. A. Marten. 1988. Genetic evidence for relationships in the avian family Vireonidae. Condor 90:428-445.

Keast, A., and E.S. Morton. 1980. Migrant birds in the neotropics: ecology, distribution, and conservation. Smithsonian Institution Press, Washington, DC.

Kelley, C. 1935. Birds of Dallas County. American Midland Naturalist 16:936-948.

Kilian, J. T. 1993. The language of environmental debate: the Balcones Canyonlands Conservation Plan. M.A. Thesis. University of Texas at Austin, Austin, Texas, USA. 72 p.

Kincaid, E. B., Jr. 1960. The Black-capped Vireo, remarkable bird of the Hill Country. Texas Game and Fish 18(4):4-5.

Kirn, A. J., and R. W. Quillin. 1927. Birds of Bexar County, Texas (checklist). Witte Memorial Museum, San Antonio, Texas, USA.

Koloszar, J. A. 1998. Field studies of the Black-capped Vireo (Vireo atricapillus) (BCVI) on Fort Hood, Texas. Pages 7-27 in Summary of 1997 research activities. Texas Conservation Data Center, The Nature Conservancy, Fort Hood, Texas, USA.

Koloszar, J. A., and J. W. Bailey. 1999. Monitoring of the Black-capped Vireo (Vireo atricapillus) during 1998 on Fort Hood, Texas. Pages 13-53 in Summary of 1998 endangered species monitoring and management activities at Fort Hood, Texas. Fort Hood Project, The Nature Conservancy, Fort Hood, Texas, USA.

Koloszar, J. A., and J. W. Bailey. 2000. Monitoring of the Black-capped Vireo during 1999 on Fort Hood, Texas. Pages 9-42 in Endangered species monitoring and management at Fort Hood, Texas: 1999 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA. 340 p.

Koloszar, J. A., and J. S. Horne. 2000. Interim report on predicting Black-capped Vireo colonization after a crown fire. Pages 43-49 in Endangered species monitoring and management at Fort Hood, Texas: 1999 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA. 340 p.

Koloszar, J. A., L. L. Sanchez, and M. E. Batchelor. 2000. Black-capped Vireo habitat manipulation: comparing hydro-axing, bulldozing, and prescribed burning for creating suitable breeding habitat. Pages 221-239 in Endangered species monitoring and management at Fort Hood, Texas: 1999 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA. 340 p.

Lacey, H. 1911. The birds of Kerrville, Texas and vicinity. Auk 28:200-219.

Lasley, G., B. Lasley, and C. Sexton. 1981. Birds of Pedernales Falls State Park; a field checklist. Texas Parks and Wildlife Department, Austin, Texas, USA.

Lasley, G. W., and C. Sexton. 1989, 1990. American Birds. 43, 1990. American Birds. 44:1158.

Lloyd, W. 1884. Black-capped Vireo. Ornithologist and Oologist 9(8):104.

Lloyd, W. 1887. Birds of Tom Green and Concho Counties, Texas. Auk 4:181-193, 289-299.

Lowe, D. W., J. R. Matthews, and C. J. Moseley. (Editors). 1990. The Black-capped Vireo, Vireo atricapillus. Pages 714-715 in The official World Wildlife Fund guide to endangered species of North America.

Marshall, J. T., and R. B. Clapp. 1999. The Black-capped Vireo in Mexico and Ft. Hood. Pages 23-39 in J. T. Marshall, Ornithological tracts on taxonomy and distribution. Privately published, Springfield, Virginia, USA. 91 p.

Marshall, J. T., R. B. Clapp, and J. A. Grzybowski. 1985. Status report: Vireo atricapillus Woodhouse, Black-capped Vireo. Unpublished report to U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico, USA.

Matthews, J. R., and C. J. Moseley (editors). 1990. The Official World Wildlife Fund Guide to Endangered Species of North America. Volume 1. Plants, Mammals. xxiii + pp 1-560 + 33 pp. appendix + 6 pp. glossary + 16 pp. index. Volume 2. Birds, Reptiles, Amphibians, Fishes, Mussels, Crustaceans, Snails, Insects, and Arachnids. xiii + pp. 561-1180. Beacham Publications, Inc., Washington, D.C.

Mayfield,H . F. 1965. The Brown-headed Cowbird, with old and new hosts. Living Bird 4:13-28.

Mayfield, H. 1960. The Kirtland's Warbler. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

Maxwell, T. C. 1979. Vireos (Aves: Vireonidae) in west-central Texas. Southwestern Naturalist 24(2):223-229.

Maxwell, T. C. 1999. Black-capped Vireos and Mohr oak. Page 90 in J. P. O'Neill (editor), Great Texas birds. University of Texas Press, Austin, Texas, USA.

McKinney, B. R. 1987. Population status of Vireo atricapillus Woodhouse in the Big Bend region of Texas--1987. Unpublished report to Office of Endangered Species, U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA.

McKinney, B. R. 1988. The status of Vireo atricapillus (Black-capped Vireo) in Brushy Canyon Preserve, Brewster Co., Texas, 1988. Unpublished report to The Texas Nature Conservancy, San Antonio, Texas, USA and Office of Endangered Species, U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA.

McKinney, L. D., and R. Murphy. 1996. When biologists and engineers collide: habitat conservation planning in the middle of urbanized development. Environmental Management 20:955-961.

Mensing, C. J. 2004. 2003 Brown-Headed Cowbird Control And Kirtland's Warbler Tour Report. US Fish and Wildlife Service, East Lansing, MI Field Office.

Miller, A. H. 1955. The avifauna of the Sierra del Carmen of Coahuila, Mexico. Condor 57:154-178.

Moore, R. T. 1928. Unusual birds and extensions of ranges in Sonora, Sinaloa and Chihuahua, Mexico. Condor 40:23-28.

Morse, G. W. 1927. Notes on the Black-capped Vireo. Oologist 44:23.

Murray, B. W., W. B. McGillivray, J. C. Barlow, R. N. Beech, and C. Strobeck. 1994. The use of cytochrome b sequence variation in estimation of phylogeny in the Vireonidae. Condor 96:1037-1054.

Murray, D. L., S. Boutin, and M. O'Donoghue. 1994. Winter habitat selection by lynx and coyotes in relation to snowshoe hare abundance. Canadian J. Zoology 72:1444-1451.

National Geographic Society (NGS). 1983. Field guide to the birds of North America. National Geographic Society, Washington, DC.

NatureServe Explorer: An online encyclopedia of life [web application]. 2002. Version 1.6 . Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer. (Accessed: June 3, 2003).

Nehrling, H. 1893. Our native birds of song and beauty. Volume 1. George Brumder, Milwaukee, Wisconsin, USA.

Neighbor, D. S. 1990. Status report: Vireo atricapillus Woodhouse, Black-capped Vireo. Unpublished report to National Park Service, Big Bend National Park, Texas, USA.

Nice, M. M. 1931. The birds of Oklahoma. Revised edition. Publications of the University of Oklahoma Biological Survey 3:1-224.

Oberholser, H. C. 1974. The bird life of Texas. The University of Texas Press, Austin, Texas, USA.

Oklahoma Department of Wildlife Conservation. 1987. Population and nesting ecology of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Performance report, project E-1-1, April 1, 1986-March 31, 1987. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 39 p.

Oklahoma Department of Wildlife Conservation. 1988. Population and nesting ecology of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Performance report, project E-1-2, April 1, 1987-March 31, 1988. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 51 p.

Oklahoma Department of Wildlife Conservation. 1989. Population and nesting ecology of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Final report, section 6, Endangered Species Act, federal aid project E-1, April 1, 1986 thru March 31, 1989. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 31 p.

Oklahoma Department of Wildlife Conservation. 1993. Ecology and management of isolated populations of the Black-capped Vireo (Vireo atricapillus) in Oklahoma. Federal aid project E-1-7, April 1, 1992-March 31, 1993. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 16 p.

Oklahoma Department of Wildlife Conservation. 1996. Black-capped Vireo survey on public land in central Oklahoma. Federal aid project E-39, September 18, 1995-September 30, 1996. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 8 p.

Oklahoma Department of Wildlife Conservation. 1998. Reproductive enhancement and population monitoring of Black-capped Vireos in Blaine County. Federal aid project E-45-1, May 1, 1997-April 30, 1998. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma, USA. 8 p.

O'Neal, K. G. 1996. Effects of prescribed burning on Black-capped Vireo habitat, territory establishment, and production. M.S. Thesis. Southwest Texas State University, San Marcos, Texas, USA. 40 p.

O'Neal, K. G., Baccus, J. T., Armstrong, W. E., Harmel, D. E. 1996. Effects of prescribed burning on Black-capped Vireo habitat and territory establishment. Transactions of the North American Wildlife and Natural Resources Conference 61:220-227.

Pease, C. M., and L. G. Gingerich. 1998. The habitat requirements of the Black-capped Vireo and Golden-cheeked Warbler populations near Austin, Texas. Unpublished report, Zoology Department, University of Texas, Austin, Texas, USA. 51 p.

Pease, C. M, and J. A. Grzybowski. 1995. Assessing the consequences of brood parasitism and nest predation on seasonal fecundity in passerine birds. Auk 112:343-363.

Phillips, A. R. 1991. The known birds of North and Middle America, part II. Denver Museum of Natural History, Denver, Colorado, USA.

Post, W. and J. W. Wiley. 1977a. The shiny cowbird in the West Indies. Condor 79:119-121.

Post, W. and J. W. Wiley. 1977b. Reproductive interactions of the shiny cowbird and the yellow-shouldered blackbird. Condor 79:176-184.

Pulich, W. M. 1961. Birds of Tarrant County. Allen & Co., Fort Worth, Texas, USA.

Ragsdale, G. H. 1880. Additional notes concerning the Black-capped Vireo in Texas. Bulletin of the Nuttall Ornithological Club 5:239.

Ratzlaff, A. 1987. Endangered and threatened wildlife and plants: determination of the Black-capped Vireo to be an endangered species. Federal Register 52(193):37420-37423.

Remsen, J. V., Jr., S. W. Cardiff, and D. L. Dittmann. 1998. Status and natural history of birds of Louisiana. I. Vireos (Vireonidae). Journal of the Louisiana Ornithological Society 4(2):59-102.

Robinson, S. K., J. A. Grzybowski, S. M. C. Brittingham, L. J. Petit, and F. Thompson. 1992. Management implications of cowbird parasitism for neotropical migrant songbirds. Pages 16-17 in National training workshop, status and management of neotropical migratory birds. Executive summaries. Estes Park Center, YMCA of the Rockies, Colorado, USA. September 21-25, 1992.

Rothstein, S. I. 1990. A models system for coevolution: Avian brood parasitism. Annual. Rev. Ecol. Syst. 21:481-508.

Rothstein, S. I. 1994. The cowbird's invasion of the far west: History, causes and consequences experienced by host species, in A century of avifaunal change in western North America (J. R. Jehl, Jr. and N. K. Johnson, eds.). Studies Avian Biol. 15:301-315.

Rothstein, S. I., and T. L. Cook. 2000. Part V. Cowbird management, host population limitation, and efforts to save endangered species. Introduction. Pages 323 - 332 in J. N. M. Smith, T. L. Cook, S.I. Rothstein, S. K. Robinson, and S. G. Sealy (editors), Ecology and management of cowbirds and their hosts. Studies in the conservation of North American Passerine birds. University of Texas Press, Austin, Texas, USA.

Rust, S. P., and D. J. Tazik. 1990. Field season report: endangered bird survey on Camp Bullis Training Reservation, Fort Sam Houston, Texas. November 1990. Unpublished report to Environmental Division, U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. Stewardship Services, Inc., San Antonio, Texas, USA.

Rust, S. P., and D. J. Tazik. 1991. 1991 field season report; endangered bird survey on Camp Bullis Training Reservation, Fort Sam Houston, Texas. Unpublished report. Stewardship Services, Inc., San Antonio, Texas, USA.

Rust, S. P., and D. J. Tazik. 1992. 1992 field season report; endangered bird survey on Camp Bullis Training Reservation, Fort Sam Houston, Texas. Unpublished report. Stewardship Services, Inc., San Antonio, Texas, USA.

Scott, J. M., and E. O. Garton. 1991. Population estimates of the Black-capped Vireo. Condor 93:469-470.

Scott, P. E. 1991. Surveys for Black-capped Vireos and Golden-cheeked Warblers in central Texas state park and natural areas, May-June 1991. Texas Parks and Wildlife Department, Parks Division, Public Lands, Austin, Texas, USA. 22 p.

Sexton, C. 1990. The association of the Black-capped Vireo with limited geologic strata in Texas. Draft manuscript. City of Austin, Environmental and Conservation Services Department, Austin, Texas, USA. 23 p. + iii tables + ii figures.

Sexton, C. 1997. Cowbirds and vireos; a short course and a success story. Bird Conservation, Summer 1997:14-15.

Sexton, C. W., and J. S. Tomer. 1991. Clarification of the type locality of the Black-capped Vireo (Vireo atricapillus). Bulletin of the Texas Ornithological Society 23:2-5.

Sexton, C. W., J. A. Grzybowski, G. W. Lasley, and R. B. Clapp. 1991. Distribution and status of the Black-capped Vireo in Texas. Unpublished manuscript.

Shaw, D. M., and S. F. Atkinson. 1990. An introduction to the use of geographic information systems for ornithological research. Condor 92:564-570.

Shaw, D. M. 1989. Applications of GIS and remote sensing for the characterization of habitat for threatened and endangered species. Ph.D. Dissertation. University of North Texas, Denton, Texas, USA. 229 p. {From Dissertation Abstracts International B Science and Engineering 51(1):54. 1990}

Shaw, D. M., and S. F. Atkinson. 1990. An introduction to the use of geographic information systems for ornithological research. Condor 92:564-570.

Shaw, D. M., D. J. Tazik, J. M. Coffey, and S. F. Atkinson. 1989. The Black-capped Vireo on Camp Bullis, Fort Sam Houston, Texas. Status report. Unpublished report submitted to the Fort Worth District Corps of Engineers, Fort Worth, Texas, USA. Center for Remote Sensing and Land-use Analyses, University of North Texas, Denton, Texas, USA.

Shull, A., "Endangered and Threatened Wildlife and Plants: Proposal to Determine the Blackcapped Vireo To Be an Endangered Species," Federal Register, Vol 51 (1986), pp 44808-44812.

Siegle, R. and D. Ahlers. 2004. Brown-headed Cowbird Management Techniques Manual. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Ecological Planning and Assessment Group. Denver, CO. 69pp.

Singley, J. A. 1887. Observations on eggs collected in Lee County, Texas. Ornithologist and Oologist 12:163-165.

Smith, A. P. 1916. Additions to the avifauna of Kerr Co., Texas. Auk 33:187-193.

Smith, A. P. 1918. Some Texas bird notes. Condor 20:212.

Stake, M. M. 1998. 1997 video predation pilot study. Pages 73-75 in Summary of 1997 research activities. Texas Conservation Data Center, The Nature Conservancy, Fort Hood, Texas, USA. 314 p.

Stake, M. M. 1999. Video predation study 1998. Pages 177-207 in Summary of 1998 endangered species monitoring and management activities at Fort Hood, Texas. Fort Hood Project, The Nature Conservancy, Fort Hood, Texas, USA.

Stake, M. M. 2000. Video monitoring of Black-capped Vireo nest predation at Fort Hood, Texas in 1999. Pages 141-145 in Endangered species monitoring and management at Fort Hood, Texas: 1999 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA. 340 p.

Steed, D. L., and L. van Hulsteyn. 1989. 1988 field program, Black-capped Vireo investigations in vicinity of Austin Outer Parkway (SH 45), Travis County, Texas. Final Report. Unpublished report to State Department of Highways and Public Transportation, Austin, Texas, USA.

Steed, D. L., L. van Hulsteyn, and R. Farmer. 1988. Black-capped Vireo investigations in vicinity of Proposed SH 45 Project, Travis County, Texas. Final Report. Unpublished report to State Department of Highways and Public Transportation, Austin, Texas, USA.

Stillwell, J. E. 1939. Checklist of the birds of Dallas County, Texas. Boyd Printing Co., Dallas, Texas, USA.

Strecker, J. K., Jr. 1912. The birds of Texas. An annotated check-list. Baylor University Bulletin Volume 15, Number 1. Waco, Texas, USA.

Strecker, J. K., Jr. 1927. The ornithology of McLennan County, Texas. Baylor University Museum Special Bulletin. No. 1. Waco, Texas, USA.

Stewardship Services, Inc. 1993. 1993 field season report: endangered bird survey on Camp Bullis Training Reservation, Fort Sam Houston, Texas. Unpublished report. Stewardship Services, Inc., San Antonio, Texas, USA.

Stuart, D., and K. Bryan. 1988. Black-capped Vireo survey and habitat evaluation at Elephant Mountain and Black Gap Wildlife Management Areas. Unpublished report. Texas Parks and Wildlife Department, Austin, Texas, USA. (This report is attached to Armstrong 1989)

Summers, S. G., G. H. Eckrich, and W. C. Holimon. 2000. Brown-headed Cowbird control program on Fort Hood, Texas. Pages 179-200 in Endangered species monitoring and management at Fort Hood, Texas: 1999 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA. 340 p.

Taylor, M. E. 1994. Promoting recovery or hedging a bet against extinction: Austin, Texas's risky approach to ensuring endangered species' survival in the Texas Hill Country. Environmental Law 24:581-602.

Tazik, D. J. 1991a. Biological assessment of the effects of military associated activities on endangered species at Fort Hood, Texas. December 1991. Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 177 p.

Tazik, D. J. 1991b. Proactive management of an endangered species on Army lands: the Black-capped Vireo on the lands of Fort Hood, Texas. Ph.D. Dissertation. University of Illinois, Urbana-Champaign, Illinois, USA. 258 p.

Tazik, D. J., and J. D. Cornelius. 1993. Status of the Black-capped Vireo at Fort Hood, Texas, volume III: distribution and abundance. USACERL Technical Report EN-94/01, Vol. III. November 1993. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 108 p. ADA277 544.

Tazik, D. J., J. D. Cornelius, and C. A. Abrahamson. 1993. Status of the Black-capped Vireo at Fort Hood, Texas, volume I: distribution and abundance. USACERL Technical Report EN-94/01, Vol. I. November 1993. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 56 p. ADA275 757.

Tazik, D. J., J. D. Cornelius, D. M. Herbert, T. J. Hayden, and B. R. Jones. 1992. Biological Assessment of the effects of military associated activities on endangered species at Fort Hood, Texas. USACERL Special Report EN-93/01. December 1992. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 142 p. ADA263 489.

Tazik, D. J., J. A. Grzybowski, and J. D. Cornelius. 1989. Habitat of the endangered Black-capped Vireo on the lands of Fort Hood, Texas. Interim report. Unpublished report submitted to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA.

Tazik, D. J., J. A. Grzybowski, and J. D. Cornelius. 1993. Status of the Black-capped Vireo at Fort Hood, Texas, volume II: habitat. USACERL Technical Report EN-94/01, Vol. II. November 1993. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 44 p. ADA275 677.

Terres, J. K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York.

The Nature Conservancy, Fort Hood, Texas, USA. 314 p.

Thompson, M. C., and C. Ely. 1992. Birds in Kansas. Volume 2. University of Kansas Museum of Natural History, Lawrence, Kansas, USA.

Thornton, W. A. 1951. Ecological distribution of the birds of the Stockton Plateau in northern Terrell County, Texas. Texas Journal of Science 3:413-430.

Tordoff, H. B. 1956. Checklist of the birds of Kansas. University of Kansas Museum of Natural History Publication 8:307-359.

Trame. A.-M., S. J. Harper, J. Aycrigg, and J. Westervelt. 1997. Fort Hood avian simulation model - a dynamic model for ecological influences on two endangered species. USACERL Technical Report 97/88. U.S. Army Corps of Engineers, Construction Engineering Research Laboratories, Champaign, Illinois, USA. 152 p. ADA327 483.

The Nature Conservancy. 1998. Summary of 1997 research activities. Compiled by L. L. Sanchez. Texas Conservation Data Center, The Nature Conservancy, Fort Hood, Texas, USA. 314 p.

The Nature Conservancy. 1999. Summary of 1998 endangered species monitoring and management activities at Fort Hood, Texas. Fort Hood Project, The Nature Conservancy, Fort Hood, Texas, USA. 250 p.

The Nature Conservancy. 2000. Endangered species monitoring and management at Fort Hood, Texas: 1999 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA. 340 p.

The Nature Conservancy. 2000. Endangered species monitoring and management at Fort Hood, Texas: 2000 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas, USA.

Trame, A.-M., S. J. Harper, and J. Westervelt. 1998. Management of cowbird traps on the landscape: an individual-based modeling approach for Fort Hood, Texas. USACERL Technical Report 98/121. September 1998. U.S. Army Corps of Engineers, Construction Engineering Research Laboratories, Champaign, Illinois, USA. 60 p.

U.S. Army Environmental Requirements and Technology Assessments (AERTA), "Environmental Technology Requirements for FY02," June 2002.

U.S. Fish and Wildlife Service (USFWS). 1987. Determination of the black-capped vireo to be an endangered species. Federal Register 52(193):37420-3.

U.S. Fish and Wildlife Service (USFWS). 1990. Endangered and threatened species recovery program: report to Congress. 406 pp.

U.S. Fish and Wildlife Service. 1991. Black-capped Vireo (Vireo atricapillus) recovery plan. U.S. Fish and Wildlife Service, Austin, Texas, USA. vi + 74 p.

U.S. Fish and Wildlife Service. 1993. Biological Opinion. Document Number 2-15-93-F-003. Letter to Commanding Officer, H. G. Taylor, LT General, U.S. Army, Headquarters III Corps and Fort Hood, Fort Hood, Texas; from U.S. Fish and Wildlife Service, Austin, Texas, USA. 21 p.

U.S. Fish and Wildlife Service. 1996. Black-capped Vireo population and habitat viability assessment report. Compiled and edited by Carol Beardmore, Jeff Hatfield, and Jim Lewis in conjunction with workshop participants. Report of a September 18-21, 1995 workshop in partial fulfillment of U.S. Biological Service Grant No. 80333-1423. Austin, Texas, USA. ix + 57 p. PB97-108864.

U.S. Fish and Wildlife Service. 2000. Environmental Assessment proposed additions to Balcones Canyonlands National Wildlife Refuge, Burnet and Travis Counties, Texas. June 2000. Albuquerque, New Mexico, USA. 65 p.

U.S. Fish and Wildlife Service. 2000. Biological Opinion. Consultation # 2-15-93-F-003. Letter to Commanding General, LTG Leon J. LaPorte, Department of the Army, Headquarters III Corps and Fort Hood, Fort Hood, Texas, USA; from U.S. Fish and Wildlife Service, Austin, Texas, USA. 20 p.

U.S. Fish and Wildlife Service, and Recon. 1996. Final environmental impact statement/habitat conservation plan for proposed issuance of a permit to allow incidental take of the Golden-cheeked Warbler, Black-capped Vireo, and six karst invertebrates in Travis County, Texas. U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA, and Recon, San Diego, USA.

Van Tyne, J., and G. M. Sutton. 1937. The birds of Brewster County, Texas. Miscellaneous Publications of the Museum of Zoology, University of Michigan 37:1-115.

Walkinshaw, L. H. 1959. The Prairie Warbler in Michigan. Jack-Pine Warbler 37:54-63.

Walkinshaw, L. H. 1983. Kirtland's Warbler: the natural history of an endangered species. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

Walkinshaw, L. H. 1989. Nest observations of the Kirtland's Warbler-a half century quest. University Microfilms International, Ann Arbor, Michigan.

Watland, A., J. Bak, S. Sekscienski, and B.Woodson. 2002. Installation Summaries From the 2001 Survey of Threatened and Endangered Species. SFIM-AEC-CD-TR-2002034 U. S. Army Environmental Center 5179 Hoadley Road, Bldg E4435 Aberdeen Proving Ground, MD 21010-5401.

Wauer, R. H., and Ligon, J. D. 1974. Distributional relations of breeding avifauna of four southwestern mountain ranges. Pages 567-578 in R. H. Wauer and D. H. Riskind (editors). Transactions of the symposium on the biological resources of the Chihuahuan desert region, United States and Mexico. National Park Service Proceedings Transaction Series No. 3. 658p.

Webster, F. S., Jr. 1962. The Black-capped Vireo in central Texas. Audubon Field Notes 16:414-417.

Webster, F. S., Jr., and C. W. Sexton. 1986. Fred S. Webster, Jr., field notes on the Black-capped Vireo. Annotated by Chuck Sexton, February 1986. Unpublished report. City of Austin, Department of Environmental Protection, Austin, Texas, USA.

Weinberg, H. J. 1998. Golden-cheeked warbler and Black-capped Vireo monitoring program on Camp Bullis, Texas. Technical report. April 1998. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 40 p. ADA341 8546.

Weinberg, H. J., J. S. Bolsinger, and T. J. Hayden. 1995. Project status report: 1994 field studies of two endangered species (the Black-capped Vireo and the Golden-cheeked Warbler) and the cowbird control program on Fort Hood, Texas. January 1995. Unpublished report to HQ III Corps and Fort Hood, Natural Resources Division, Directorate of Engineering and Housing, Fort Hood, Texas. Natural Resources Division, U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 71 p.

Weinberg, H. J., T. J. Hayden, and J. D. Cornelius. 1998. Local and installation-wide Black-capped Vireo dynamics on the Fort Hood, Texas Military Reservation. USACERL Technical Report 98/54. March 1998. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 62 p. ADA341 156.

Weinberg, H. J., L. A. Jetté, and J. D. Cornelius. 1996. Project status report: 1995 field studies of two endangered species (the Black-capped Vireo and the Golden-cheeked Warbler) and the cowbird control program on Fort Hood, Texas. January 1996. Unpublished report to HQ III Corps and Fort Hood, Natural Resources Branch, Directorate of Public Works, Fort Hood, Texas, and Natural Resources Assessment and Management Division, U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA. 78 p.

Weir, R. D. 1991. The spring season, March 1-May 31, 1991, Ontario region. American Birds 45:439-443.

Whitten, M. L. 1999. The relationship between surface transportation policies and endangered species policies in Texas: an analysis of the Texas Department of Transportation's effort to incorporate endangered species protection into its highway operations. Master of Public Affairs report. University of Texas at Austin, Austin, Texas, USA. 171 p.

Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Wolfe, L. R., Colonel. 1965. Check list of birds of Kerr County, Texas. Privately published.

Woodhouse, S. W. 1852. Descriptions of new species of the genus Vireo, Vielle, and Zonotrichia, Swains. Proceedings of the Academy of Natural Sciences, Philadelphia 6:60.

3 Species Profile for the Golden-Cheeked Warbler

Golden-cheeked Warbler[1]

Dendroica chrysoparia

Status

On May 4, 1990, the golden-cheeked warbler was placed on the Federal Endangered species list by means of an emergency rule due to significant declines in population, reductions of overall range, and continuing loss of nesting habitat in several key counties.

Description

A very handsome songbird, the golden-cheek measures from 11.4 to 12.7 cm long with a wingspan of 20.3 cm. The male has a black back, throat, and cap with snappy yellow cheeks with a black stripe through the eye. Females and immatures are duller, the upperparts being olive with dark streaks and the chin yellowish or white; sides of throat are streaked; belly is white. Note the lower breast and belly of both sexes are white with black streaks on the flanks. Birds similar in appearance include close relatives the black-throated green warbler and Townsend's warbler sometimes seen in the company of golden-cheeks during migration. Check facial pattern, back color and lower breast and belly color to differentiate species.

Population

Pulich (1976) estimated the total population in 1974 at 15,000 to 17,000 individuals. A reassessment in 1990 suggested that only 4,800 to 16,000 pairs could be supported in available breeding habitat (Collar et al. 1992). According to Ehrlich et al. (1992), an estimated 2,200 to 4,600 remained in 1990. The global abundance is estimated at 2,500 to 10,000 individuals.

Analysis of golden-cheeked warbler point-count survey data from 1992 through 2001 indicated a significant increase in population size at Fort

[1] NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 16, 2006). US FWS ES. Species Account: Golden-cheeked Warbler. http://www.fws.gov/endangered/i/a/saa4l.html (Accessed June 16, 2006).

Hood. During this 10-yr period, the mean number of golden-cheeked warblers detected at each survey point almost doubled. The increase in population size has not yet leveled off, suggesting that breeding habitat at Fort Hood might not yet be saturated (Anders et al. 2004).

Distribution

The golden-cheeked warbler is a rare species with one of the most restricted breeding ranges in all of North America. Texas is the only state where this bird nests (Figure 3-1). Except for two fall migration records from Florida and the Farallon Islands off California, this bird has never been found anywhere else in the United States. Unfortunately, the impacts of a century and a half of urbanization and land-clearing for agriculture have conspired to reduce numbers of this beautiful bird to an estimated 5,000 to 15,000 pairs confined to an area of 30+ counties in the Edwards Plateau, Lampasas Cut Plains, and Llano Uplift.

Winter Distribution and Migration: Golden-cheeks winter in the pine-oak highlands of southern Mexico and Central America from southern Chiapas, Guatemala, Honduras, and Nicaragua (orange on Figure 3-1). The species migrates over land from there through the mountains of the Sierra Madre Oriental of Mexico passing through the states of Chiapas, Veracruz, Queretaro, Coahuila, Nuevo Leon, and Tamaulipas till they reach their Texas breeding grounds (blue on Figure 3-1).

Figure 3-1. Distribution map of the golden-cheeked warbler.

Habitat

Golden-cheeks are strict habitat specialists found breeding only in "cedar brakes" of the Texas Hill Country. In the words of Guilfoyle (2002) "Golden-cheeked warblers are restricted to mature Ashe juniper stands mixed with other deciduous tree species, particularly oaks." Prime nesting habitat consists of tall, dense, mature stands of Ashe juniper mixed with hardwoods such as plateau live oak, Texas red oak, shin oak, Texas ash, cedar elm, Arizona walnuts, escarpment black cherry, and hackberries. This type of woodland thrives in relatively moist areas such as steep-sided canyons and slopes dotted with springs and seeps. Where you find steep canyons with old junipers and thick patches of hardwoods cloaking the sides, deciduous trees along drainage bottoms, creeks, and draws, you will find the bird enjoying an ideal mix of vegetation. They can also be found in lower densities in drier, flatter upland juniper-oak habitats consisting of post oak, live oak, and blackjack oak, but this is not considered their prime habitat.

Warblers require a combination of mature Ashe juniper and hardwoods in their nesting habitat. Common questions asked include: Why do they need mature trees? and How old does a juniper have to be to consider it mature? Mature juniper trees vary in age and growth form, depending on many factors on the site where they are growing. Soils, moisture, aspect, slope, and location as well as past land use practices all play a role. Trees that have shredding bark, at least near the base, are an essential element of the nesting territory, as the females use this bark to construct the nest. Trees need to be at least 20 to 30 years old and 4.5 meters tall before they show this quality. Interestingly, no other species of juniper occurring within the bird's range provide acceptable nesting material for the female golden-cheek.

Habitat structure is also important. Birds prefer wooded areas with a moderate to high density of trees with dense foliage in the upper canopy. They prefer large tracts over small isolated tracts, a good mix of juniper and hardwoods with variability in tree heights and lots of deciduous tree cover. A pure stand of scrubby juniper is not ideal habitat at all. Ideal habitat must also have water. Proximity to water is essential for drinking and bathing. Prime habitat also seems to occur on steep canyon slopes with rugged terrain, perhaps because of the greater surface run-off and seepage that occurs there. This favors luxuriant growth of deciduous trees and

more insect food production. Fires historically don't affect steep slopes nor are they practical for agricultural clearing which may also be key factors.

Much discussion has taken place as to whether golden-cheeks are "edge species." Most ornithologists, however, do not concur with this description citing the obvious; if it were an edge species, it should have benefited from all the habitat fragmentation that has occurred in recent decades and should thus be increasing rather than declining. All available evidence suggests that golden-cheeks need large tracts of undisturbed habitat in order to thrive. It tends to disappear as areas become isolated in a sea of development, fragmented, and increasingly urbanized.

Threats and Reasons for Decline

Threats: The habitat has diminished due to juniper eradication programs and continuing urbanization (e.g., around Austin, San Antonio, and Waco, USFWS 1990). The species suffers from heavy cowbird parasitism, which may be increasing as habitat becomes fragmented. It is potentially threatened by a widespread Mediterranean fruit-fly eradication program (using malathion) proposed for Guatemala (in Collar et al. 1992).

Reasons for Listing: Probably the most serious threat facing the golden-cheek, given its highly restricted breeding range, is habitat loss and fragmentation due to urbanization and clearing associated with agriculture. Fragmentation has resulted directly in significant declines in the population. Previously, the principal reason for habitat loss was the clearing of juniper to improve pasture conditions for cattle grazing, to provide wood for fence posts, cedar oil, and furniture. Recent losses have occurred especially in Bexar, Travis, and Williamson counties due to rapid suburban development, urbanization, and reservoir construction and creation of impoundments for flood control. There have also been losses of habitat on the wintering grounds and through the migration corridor. Foremost is the clearing and logging of the pine-oak woodlands for commercial lumber, charcoal, marble quarrying, and habitation in the highlands of Guatemala, Honduras, and Nicaragua. As human populations continue to soar, this will continue. Another factor is the loss of oaks to oak wilt and a general reduction in the regeneration of many oak species. In some areas where there is an overpopulation of white-tailed deer, over-browsing is a problem. Goats and various other exotic ungulates also contribute to over-browsing, which reduces the quality of the habitat. Brown-headed cowbird parasitism is a major cause of concern and concentrations of livestock may

elevate rates of nest parasitism in some areas. Creation of edge due to fragmentation increases the probability that natural nest predators like raccoons, opossums, squirrels, scrub and blue jays, and feral cats will find warbler nests. Fragmentation definitely helps the brown-headed cowbird locate warbler nests. Fragmentation also increases the distance between habitat patches making recolonization of vacant habitat more difficult.

Other Information

Foraging: Golden-cheeks feed almost entirely on insects, especially soft-bodied caterpillars, spiders, beetles, and other small critters found in the foliage of the tree canopy. They tend to avoid the spiny type caterpillars. Oaks are especially important as foraging trees during the nesting season. Relatively moist conditions such as those found in canyon bottoms, along draws and creeks, and cool wooded slopes are great for the production of insects.

Territory and Nesting: Male golden-cheeks arriving in mid-March will set up a territory from 1.2 to 2.4 ha, which he will defend vigorously through song against all other males of the species. Territories in prime habitat tend not to be as large and those in suboptimal habitats. The female alone builds the nest. Golden-cheek nests are sublime examples of near-perfect camouflage. They are perhaps the hardest to find for biologists doing nest surveys. Because the blend so perfectly with their surroundings, you need sharp eyes, a keen search image, and tenacity to find one. Adding to the difficulty is the relatively high nest level, averaging 4.6 meters (1.5 to 7 meters) off the ground. In late March and early April the female lays a single clutch of 3 to 4 eggs. Golden-cheeks usually lay only one clutch of eggs, unlike cardinals and mockingbirds, permanent residents, who may fledge up to three broods during a summer. Exceptionally, should a first clutch be destroyed or predated early in the season, golden-cheeks will renest. The female performs the incubation, but the male stays close defending the territory and singing loudly from his favorite song posts. Eggs hatch in 12 days and young fledge 8 or 9 days after. The male takes on more paternal responsibilities as the fledglings continue to grow. At this time, family groups can be found both on territory and in creek bottoms on foraging trips.

Natural Enemies: Golden-cheeks have a number of natural enemies, including rat snakes and coach whips, that climb up trees to the open-cup nest and eat eggs or a brood of nestlings. Scrub jays and especially blue

jays have been cited as both egg and nestling predators. With the increase in urbanization, a large increase in the blue jay population has put extra strain on a declining warbler population. Other common predators include Virginia opossum, fox squirrel, great-tailed grackles, and possibly ring-tailed cats. Fire ants have also been mentioned. They can eat hatchlings, cause adults to desert the nest by stinging the brood patch of the female while she is sitting on the eggs, and probably by reducing the invertebrate prey base.

As with the black-capped vireo, one of the biggest natural enemies to the warbler is the brood parasite, the brown-headed cowbird. Cowbirds search out nests of other species and lay their eggs for the host species to bring up. They will wait for the female of the host to lay her first egg. When the potential host has left to forage, the female cowbird will remove the egg and lay one of her own. Many bird species do not recognize their own eggs. Cowbird eggs tend to hatch 1 or 2 days earlier than the warbler eggs. This gives the baby cowbird a big jump on the baby warbler in both size and noisiness. Cowbirds do not specialize or target particular host species. There is no egg mimicry or mouth mimicry as there is in the common cuckoo or some Estrildid brood parasites, which specialize on a single species each. Cowbirds will lay their eggs in any nest they find. With the impartiality of a roulette wheel, the cowbird distributes its eggs. The probability that a nest will get cowbird attention depends on the number of cowbirds laying eggs in the area and the number of host nests available. Thus, the cowbird's effects on a vulnerable host like the golden-cheek or black-capped Vireo is particularly insidious since it is unrelenting even though the host species is vanishing. The cowbird is not deterred by the scarcity of one host. The very last nest of a vanishing species is just as likely to be used as the nest of a plentiful species. From the cowbird's point of view, it is a simple numbers game: Lay enough eggs in enough different baskets and you are bound to get your genes in the next generation. While some species like the gray catbird and yellow warbler have evolved strategies against the cowbird, most deep forest species have not. Golden-cheeks can raise one of their own chicks if there is only one cowbird egg. Black-capped vireos are always doomed to nest failure should even one cowbird egg be laid in their nest. With golden-cheeks, abandonment of first clutches, or raising cowbird young in addition to one of their own, still decreases the total number and survivability of golden-cheek young produced. Feral, domestic, and stray cats associated with suburban and urban

areas play havoc with all types of songbirds including golden-cheeks. Again, losses are more devastating to species that are already in decline.

Military Installation Context: As noted in several places, each of the historic and ongoing threats is, or was, present to some degree on military installations within the bird's range. The Army, especially Fort Hood, has invested large sums into development of programs designed to mitigate or moderate these effects.

Reproduction Comments: Eggs are laid from April through June; May and June nests evidently represent renesting after failed first tries. Clutch size is 3 to 5 (usually 4). Incubation, by the female, lasts about 12 days. Young are tended by both parents, fledge in about 9 days, and may accompany an adult for 30 to 40 days after fledging. The species raises a single brood each year. It nests usually in loose groups of fewer than 6 pairs (sometimes up to 21 pairs, Pulich 1976). It will desert a nest and renest if parasitized by cowbird; renestings tend to be more successful (Morse 1989).

Ecology Comments: At Fort Hood, territories averaged 4.15 ha (in Ladd and Gass 1999). In Kendall County, territories were smaller averaging 1.72 ha (n=14; in Ladd and Gass 1999).

The dispersal distance for adult males (median year-to-year distance between territories) was estimated to be 141 m (average 223 m, range 0 to 3,523 meters, n=74; Jette et al. 1998).

In Chiapas, golden-cheeks occurred almost exclusively in mixed-species flocks (Vidal et al. 1994). Species co-occurring most frequently in flocks were Wilson's warbler (*Wilsonia pusilla*), black-throated green warbler (*Dendroica virens*), hermit warbler (*D. occidentalis*), Townsend's warbler (*D. townsendi*), and blue-headed vireo (*Vireo solitarius*, Rappole et al. 1999).

Migration Comments: The species arrives on breeding grounds in early to mid-March (Pulich 1976). It departs on southward migration mid-June; most are gone by the end of July, although some are present to early August (Wauer 1996, Ladd and Gass 1999). It is reported on wintering grounds in Chiapas, Mexico, from early August to early April (Vidal et al. 1994). Most migrants pass through a narrow Mexican cloud-forest along

the eastern slope of the Sierra Madre Oriental (Perrigo et al. 1990, Ehrlich et al. 1992).

Nonbreeding Habitat Issues: In migration and winter, the species occurs mainly in montane pine or pine-oak association (Vidal et al. 1994); recently it has been recorded in broadleaf associations in lower montane wet and tropical forest (in Collar et al. 1992). In Honduras and Guatemala, it is found primarily above 1,300 m in pine-oak forest (Rappole et al. 1999) where the dominant pine species was ocote (*Pinus oocarpa*) the and dominant oaks were "Encino" oaks (*Quercus sapotifolia, Q. eliptica, Q. elongata, and Q.cortesii,* (Rappole et al. 1999).

Army Installations Concerned

The following Army installations report presence of the golden-cheeked warbler on their property: Fort Hood, TX; Camp Bullis, TX; and Fort Sam Houston, TX.

Summary of the Recovery Plan for the Golden-Cheeked Warbler

U.S. Fish and Wildlife Service, 1992[2]

Current Species Status: The golden-cheeked warbler is listed as endangered. Habitat destruction in the breeding range has accelerated (Wahl et al. 1990) since the initial surveys of Pulich (1976). Clearing of pine-oak woodlands in Mexico and Central America is eliminating habitat on the winter range and migration corridor.

Habitat Requirements and Limiting Factors: During the breeding season, golden-cheeked warblers inhabit woodlands containing Ashe juniper (*Juniperus ashei*) in combination with various deciduous trees such as Texas oak (*Quercus bucklevi*), scaly bark oak (*Q. sinuata var. breviloba*), and plateau live oak (*Q. fusiformis*).

The essential breeding season requirement is the presence of suitable nesting material in the form of bark strips from Ashe junipers. Other limiting factors may include availability of arthropod prey, a moderate to high de-

[2] U.S. Fish and Wildlife Service. (1992). "Golden-cheeked Warbler (Dendroica chrysoparia) recovery plan," U.S. Fish and Wildlife Service, Albuquerque, NM.

gree of canopy cover, nest parasitism and predation, and proximity to water.

Recovery Objective: Delisting.

Recovery Criteria: The golden-cheeked warbler will be considered for delisting when (1) sufficient breeding habitat has been protected to ensure the continued existence of at least one viable, self-sustaining population in each of eight regions outlined in the plan, (2) the potential for gene flow exists across regions between demographically self-sustaining populations where needed for long-term viability; (3) sufficient and sustainable non-breeding habitat exists to support the breeding populations, (4) all existing golden-cheeked warbler populations on public lands are protected and managed to ensure their continued existence, and (5) all of these criteria have been met for 10 consecutive years.

Actions Needed:

- Studies of golden-cheeked warbler population status and biology, ecology, habitat requirements, and threats on the breeding ground and in the winter range and along their migration corridor.
- Protection of existing populations and habitat in the breeding range, wintering range, and along the migration corridor.
- Increased voluntary protection of warbler habitat.
- Enhancement and maintenance of the quality of warbler habitat on public and private lands.
- Increased public awareness of the importance of the species and other endangered species.
- Regulatory protection.

Management: The first step in managing golden-cheeked warbler populations is to identify known breeding areas. Areas of canyon slopes and creek bottoms with mature forests of mixed Ashe juniper and hardwoods should be identified and protected as areas with the highest probability of supporting breeding golden-cheeked warblers. Mature forested areas with 50 percent or greater canopy cover in flat or rolling uplands are also likely to attract breeding warblers. Additionally, patchy woodlands containing mature oaks and junipers may be used by golden-cheeked warblers. Although patchy woodlands may not attract breeding individuals, or may not represent ideal breeding habitat, these areas may support fledglings after the peak breeding period (Campbell 1995). Patchy or flat woodlands sur-

rounding ideal breeding habitat can function as a buffer and may serve to protect golden-cheeked warbler populations from other land-use practices, including cattle grazing, urban growth, and agricultural practices.

A woodland buffer of approximately 91.5 m around patches of high quality breeding habitat is suggested (Campbell 1995). Once breeding areas are identified, it is recommended that these areas be protected and disturbance minimized. Minimal disturbance appropriate for golden-cheeked warblers will depend on the area of forest tract being protected. In general, it is advised that fencelines, roads, and livestock watering areas be placed outside of identified warbler habitat. In large tracts, linear openings of 5 m or less should not significantly degrade the habitat. Also, removal of juniper trees 3 m or less for use as fence posts should have a minimal impact on habitat quality for the golden-cheeked warbler (Campbell 1995). However, all planned disturbances should occur during the nonbreeding season. Habitat loss and degradation are the primary factors negatively impacting golden-cheeked warbler populations; therefore, habitat restoration is strongly recommended. Golden-cheeked warblers are reported to colonize and use restored areas, justifying habitat restoration as a primary tool in the management of this species.

As with the black-capped vireo, planned restoration efforts should focus on increasing the size of small forest tracts, linking other isolated tracts, and reducing overall fragmentation of the landscape. Although golden-cheeked warblers have been reported to breed in tracts as small as 5 ha, much larger tracts are likely needed to maintain populations (Campbell 1995). Efforts should focus on restoring forest tracts of 20 ha and larger. Restoration efforts should occur on areas where Ashe juniper is currently found or was found formerly. Lowland, mesic sites, especially areas with steep slopes, are the best sites to restore for golden-cheeked warblers. Early successional areas where young junipers are dominant should be thinned to promote hardwood regeneration. Prescribed burning may also be used to control dense stands of juniper. Intensive grazing may prevent the establishment of hardwood seedlings; therefore, grazing should be deterred and deer herds should be controlled when possible.

Military Installation Context: In the context of Army and other military installation needs, note that each of the six needed actions mentioned above is presently taking place on all installations where the species is

found. The degree of success is not clearly known at this time, but all efforts appear promising.

Juniper "Control" Programs: One aspect of management for cattle in Texas is that the Ashe juniper, the same tree required for the golden-cheeked warbler, is considered an invader of rangelands. Thus, range management guidance, even educated management guidance, may miss the interaction here among the vireo, the warbler, and the Ashe juniper. A recent pamphlet from the Texas Agricultural Experiment Station *Juniper Biology and Management in Texas* (Lyons et al. 1998) devotes almost all of its coverage to ways to reduce or eliminate junipers, but does contain this caveat, though it is probably not worded strongly enough to meet requirements of the Endangered Species Act.

> The only endangered species that requires juniper is the golden-cheeked warbler. Golden-cheeked warblers are often found in closed canopy ashe juniper-oak woodlands along streams and/or canyon slopes in the eastern part of the Edwards Plateau. Deciduous hardwoods associated with the ashe juniper provide insects for feeding, nest sites and perches. The golden-cheeked warbler requires shredding bark from mature ashe juniper to build its nest. There are no records of this bird being associated with pure stands of redberry juniper. Black-capped vireos do not require ashe juniper, but use plants associated with the juniper such as shinoak, Texas persimmon and sumac. The Endangered Species Act must be considered before ashe juniper is cleared. Thirty-three counties are currently designated as potential golden-cheeked warbler habitat. At present, stands of juniper less than 10 feet tall do not constitute critical habitat and can be cleared. However, several other criteria should be considered, including the possibility of habitat fragmentation. Fragmentation occurs when large blocks of suitable habitat become smaller and are subdivided. The size of fragmented habitat or its location relative to additional habitat may not be suitable for many wildlife species.

To enhance and protect wildlife habitat and to increase or maintain the real estate value of rangeland, consider brush sculpting rather than brush clearing. Sculpting includes:

- Following land contours and avoiding long, straight lines.
- Keeping brush on hilltops and along drainages.

- Marking and keeping brush species such as Texas oak, bumelia, and hackberry.
- Leaving scattered mottes of brush within clearings.

Management Actions for Recovery: The golden-cheeked warbler recovery plan (USFWS, 1992) includes the following land management recommendations (slightly abridged here) to support recovery. Each recommendation is relevant to the military installation context. So far as may be determined, the Endangered Species Management Plans of all military installations within the warbler's habitat follow them.

Enhance and maintain the quality of golden-cheeked warbler habitat on public and private lands. Focal areas and associated habitat should be managed to enhance and maintain the quality of GCW habitat. Factors such as oak wilt, overbrowsing, and cowbird parasitism may progressively reduce habitat quality and population viability in focal areas unless appropriate habitat management procedures are applied. Appropriate habitat management procedures should be developed and monitored to identify their benefit to the species.

Maintain hardwood regeneration within golden-cheeked warbler management sites. Populations should be protected against the effects of oak wilt and overbrowsing. Activities that make oaks more susceptible to oak wilt, such as moving infected firewood from place to place, should be avoided. Populations of white-tailed deer, goats, exotic ungulates, and other browsing animals within the habitat of the target populations may need to be managed to ensure hardwood regeneration. The response of the species to these practices should be researched and monitored.

Promote the regeneration of oak-juniper woodlands in certain areas previously cleared, thinned, or burned. In some areas targeted for golden-cheeked warbler populations, enhancement of habitat may be desirable. In those areas, where secondary succession of pure junipers occurs and the birds are not present, scattered younger juniper may be thinned and replaced with hardwood seedlings. This process should be monitored to see if the birds will colonize such managed stands. Conversely, juniper could also be encouraged in areas where they have been cut out and where mature hardwoods remain.

Develop management guidelines for formation of golden-cheeked warbler habitat. It may be advisable to allow adjacent patches of warbler habitat either to coalesce into a single continuous expanse of habitat or be divided to create edge. Woodland/grassland interfaces that are irregular may need to regrow so the resulting interface is relatively smooth. Additional fragmentation of blocks of habitat with trails, roads, fenceline rights-of-way, or any other types of right-of-way may need to be avoided.

Adopt management strategies that reduce the impact of cowbird parasitism and nest predation on golden-cheeked warbler populations. If cowbird parasitism or predation is a threat to the recovery of the golden-cheeked warbler, methods to reduce the number or productivity of female cowbirds and potential warbler predators in the vicinity of GCW populations, or otherwise reduce population-wide rates of nest parasitism and predation, may be necessary. Experimental nest predator and nest parasite removal programs may be appropriate. This approach may be the only feasible way to maintain productivity of some GCW populations, although it is considered a short-term solution. Localized threats may have to be addressed at some sites where they are seriously impacting the warbler population. These determinations can be made on a site-by-site basis. If predator control is contemplated, careful consideration should be given to determining its necessity and ecological impact prior to implementation.

Minimize the extent to which golden-cheeked warblers are affected by agriculture and urbanization. Urban and agricultural activities that might increase rates of predation, nest parasitism, and disturbance of GCWs should be limited.

Develop management guidelines and provide technical assistance to landowners. Interim guidelines should be formulated to provide management options a landowner or manager could adopt that would benefit the species. Especially included should be how to integrate warbler needs into existing land management programs. This could be developed through existing networks such as the Texas Agricultural Extension Service, the Soil Conservation Service, Texas Parks and Wildlife Department, or other state, local, and federal technical guidance programs that reach private landowners.

Conservation Plan From Fort Hood, TX (2003)

Conservation Actions: Golden-cheeked Warbler[3]

Objective 1: Maintain sufficient habitat to support a minimum carrying capacity of 2,000 singing males.

Population viability analyses indicate that a habitat carrying capacity lower than that necessary to support a maximum of 1,000 singing male golden-cheeked warblers greatly increases the probability of extinction (Hayden et al. 2001). Increasing carrying capacities above 1,000 singing males does not significantly alter the probability of extinction. Carrying capacity represents the maximum potential of the habitat to support singing males. Carrying capacity does not necessarily reflect the number of singing males normally expected to occur. However, increases in carrying capacity above 1,000 singing males does increase the expected number of singing males present. Maintaining carrying capacity in excess of 1,000 singing males also provides some buffer in the event of catastrophic loss of habitat or birds. A carrying capacity of 2,000 exceeds the threshold for increased extinction risk and provides capacity for the presence of substantial numbers of singing males in excess of current USFWS recovery goals.

Objective 2: Implement training restrictions in designated "core" habitats in accordance with Fort Hood Endangered Species Training Guidelines.

Military training in areas occupied by golden-cheeked warblers can destroy habitat and disturb individuals, potentially resulting in reduced abundance and productivity. These impacts increase the possibility of "take" as defined in the Endangered Species Act. The Fort Hood Biological Opinion (16 March 2005) states that implementation of the Fort Hood Training Guidelines in golden-cheeked warbler habitat will assist in minimizing effects of incidental take related to military training activities. "Core" habitat areas designated under this objective were selected based on known population distributions, quality and contiguity of habitat, and minimal mission conflicts.

---

[3] Hayden, T. J., J.D. Cornelius, and P.A. Guertin. Endangered Species Management Plan for Fort Hood, TX. Technical Report Draft FY06-10 Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA.

Objective 3: Implement a sustainable incidental take limit for the 5-year term of this Endangered Species Management Plan.

The intent of this ESMP is to promote recovery of endangered species on Fort Hood lands while permitting the military maximum flexibility to perform mission essential tasks. Current estimates of available golden-cheeked warbler habitat on Fort Hood exceed population and recovery goals under this ESMP. Implementation of incidental take limits provides flexibility for conducting mission activities that may result in habitat loss. However, this potential habitat loss is limited so as to not jeopardize base-line habitat requirements and to provide an adequate habitat mitigation bank in perpetuity without implementing further restrictive measures on the military mission. Habitat "loss" as defined under this ESMP is any permanent or temporary alteration of currently suitable habitat to the extent that it is unsuitable for occupation by breeding adults.

Objective 4: Maintain currently available habitat consistent with population carrying capacity goal and essential mission requirements.

Fort Hood currently provides sufficient habitat to meet population carrying capacity goals under this ESMP and to exceed USFWS recovery objectives. Limited opportunities exist to further increase habitat availability. Maintenance of these habitats in excess of USFWS recovery goals will promote the long-term survival of the species, which is in the interest of the Army and Fort Hood to achieve greater training flexibility.

Objective 5: Document golden-cheeked warbler population trends and factors affecting population status.

Population change is the base-line measure of conservation success and recovery for the population. This measure is necessary to differentiate between normal annual variability and true trends in populations over time. Evaluation of factors affecting populations allows a determination of population change due to natural or stochastic processes versus change due to human land use practices.

The Vireo-Warbler Conflict

The black-capped vireo and the golden-cheeked warbler share a portion of their range in central Texas. Both are found in areas of mixed shrubs and

grassland; however, the vireo is associated with an early successional stage dominated by scrub oaks, and avoids areas where juniper has developed a denser cover. The warbler is favored by the juniper-dominated habitat. The requirements for the warbler are stated thus: (Guilfoyle 2002) "Golden-cheeked warblers are restricted to mature Ashe juniper stands mixed with other deciduous tree species, particularly oaks...The bark from the Ashe juniper tree is an integral component of the golden-cheek warbler's nest." This ERDC technical note by Guilfoyle describes the problems of managing simultaneously for two species whose habitat requirements inherently conflict. It was directed toward reservoir operations, but is equally applicable to the military installations.

References

References cited in this chapter and selected additional sources for more information.

Anders, A. D., and D. C. Dearborn. 2004. Population trends of the endangered golden-cheeked warbler at Fort Hood, Texas, from 1992-2001. Southwestern Naturalist 49:39-47.

Askins, R. A. 1993. "Population trends in grassland, shrubland, and forest birds in eastern North America," Current Ornithology. Vol. 11, D. M. Power, ed., Plenum Publishing Corporation, New York, 1-34.

Baccus, J. T., Nelka, J. and Harmel, D. 1997. "Assessment of burning and juniper control on black-capped vireo habitat," http://www.tpwd.state.tx.us/hunt/research/bcvhab.htm (29 Oct 2001).

Benson, R. H., and Benson, K. L. P. 1990. "Estimated size of Black-capped Vireo populations in Coahuila, Mexico," Condor 92, 777-779.

BirdLife International. 2004. Threatened birds of the world 2004. CD ROM. BirdLife International, Cambridge, UK.

Collar, N.J., L.P. Gonzaga, N. Krabbe, A. Madrono-Nieto, L.G. Naranjo, T.A. Parker III, and D.C. Wege. 1992. Threatened Birds of the Americas. The ICBP/IUCN Red Data Book. Third Edition. Part 2. Smithsonian Institution Press, Washington, DC. 1150 pp.

Campbell, L. 1995. "Endangered and threatened animals of Texas: Their life history and management," Texas Parks and Wildlife Press, Austin, TX.

Cathey, K. 1997. "The endangered birds of Balcones Canyonlands National Wildlife Refuge," Endangered Species Bulletin, 22(5), 20-21.

Damude, Noreen. 2001.The Golden-cheeked Warbler and Black-capped Vireo Biology and Natural History, Texas Parks and Wildlife, Austin, TX

DeGraaf, R. M., and Rappole, J. H. 1995. "Neotropical migratory birds: Natural history and population change," Comstock Publishing Associates, Ithaca, NY.

Dickerson, D., Martin, C. O., and Allen, H. H. 1999. "Effects of reservoir operations on individual species and communities," U.S. Army Engineer Research and Development Center EMRRP Information Exchange Bulletin 2 (2):1-4.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1992. Birds in Jeopardy: the Imperiled and Extinct Birds of the United States and Canada, Including Hawaii and Puerto Rico. Stanford University Press, Stanford, California. 259 pp.

Fischer, R. A., and Guilfoyle, M. P. 2001. "Recommendations for long-term monitoring of the endangered golden-cheeked warbler on Camp Bullis, TX," U.S. Army Engineer Research and Development Center, Conservation Assistance Program, Final Report, Vicksburg, MS.

Graber, J. W. 1961. "Distribution, habitat requirements, and life history of the Black-capped Vireo (Vireo atricapillus)," Ecological Monographs 31:313-336.

Gryzbowski, J. A. 1995. "Black-capped Vireo (Vireo atricapillus)," The Birds of North America, No. 181, A. Poole, and Gill, F., eds., The Birds of North America, Inc., Philadelphia, PA.

Guilfoyle, M. P. 2002. "Black-capped vireo and golden-cheeked warbler populations potentially impacted by USACE reservoir operations," EMRRP Technical Notes Collection (TN EMRRP-SI-28), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp

Hayden, T. J., J.D. Cornelius, and P.A. Guertin. Endangered Species Management Plan for Fort Hood, TX. Technical Report Draft FY06-10 Unpublished report to HQ III Corps and Fort Hood, Directorate of Engineering and Housing, Fort Hood, Texas. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois, USA.

Jette, L. A., Hayden, T. J., and Cornelius, J. D. (1998). "Demographics of the Golden-cheeked Warbler () on Fort Hood, Texas," Technical Report 98/52, USACERL, Champaign, IL.

Johnson, K. W., Johnson, J. E., Albert, R. O., and Albert, T. R. 1988. "Sightings of Golden-cheeked Warblers (Dendroica chrysoparia) in northwestern Mexico," Wilson Bulletin 100, 130-131.

Kasul, R. L., Martin, C. O., and Allen, H. H.(2000. "Characterization of sensitive species and habitats affected by operations of USACE water resource development projects," EMRRP Technical Notes Collection (TN EMRRP-SI-10), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp

Kroll, J.C. 1980. Habitat requirements of the golden-cheeked warbler: management implications. J. Range Manage. 33:60-65.

Ladd, C., and Gass, L. 1999. "Golden-cheeked Warbler (Dendroica chrysoparia)," The Birds of North America, No. 420, A. Poole, and Gill, F., eds., The Birds of North America, Inc., Philadelphia, PA.

Lockwood, M. W. 1996. "Courtship behavior of Golden-cheeked Warblers," Wilson Bulletin 108, 591-592

Lyons, Robert K., M. Keith Owens and Richard V. Machen. 1998. Juniper Biology and Management in Texas. Texas Agricultural Experiment Station Bulletin B-6074, September 1998

Mitchell, W. A., Martin, C. O., and Dickerson, D. 2000. "Assessment of activities for selected threatened and endangered species at Corps projects," Unpublished manuscript, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS.

Morse, D.H. 1989. American warblers: an ecological and behavioral perspective. Harvard University Press, Cambridge, MA. 406 pp.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer . (Accessed: June 16, 2006).

Perrigo, G., et al. 1990. Spring migration corridor of golden-winged warblers in Tamaulipas, Mexico. Am. Birds 44:28.

Pulich, W.M. 1976. The Golden-cheeked Warbler: a bioecological study. Texas Parks and Wildlife Department. Austin, TX. 172 pp.

Rappole, J.H., D.I. King, and W.C. Barrow, Jr. 1999. Winter ecology of the endangered Golden-cheeked Warbler. Condor 101(4):762-770.

Rothstein, S. I. 1994. "The cowbird's invasion of the far west: History, causes, and consequences experienced by host species," A century of avifaunal change in western North America," J. R. Jehl, Jr., and Johnson, N. K., ed., Studies in Avian Biology No. 15. Allen Press, Inc., Lawrence, KA, 301-315.

Scott, J. M., and Garton, E. O. 1991. "Population estimates of the Black-capped Vireo," Condor 93, 469-470.

Schreiber, E. R., and Reed, M. A. (1999). "Installation summaries from the 1998 survey of threatened and endangered species on Army lands," CERL Technical Report 99/78, U.S. Army Engineer Research and Development Center, Champaign, IL.

Tazik, D. J., and Cornelius, J. D. 1993. "Status of the Black-capped Vireo at Fort Hood, Texas, volume III: Population and nesting ecology," Technical Report EN-94/01, U.S. Army Engineer Research and Development Center, Champaign, IL.

Tazik, D. J., Cornelius, J. D., and Abrahamson, C. A. 1993. "Status of the Black-capped Vireo at Fort Hood, Texas, volume I: Distribution and abundance," Technical Report EN-94/01, U.S. Army Engineer Research and Development Center, Champaign, IL.

Tazik, D. J., Grzybowski, J. A., and Cornelius, J. D. 1993. "Status of the Black-capped Vireo at Fort Hood, Texas, volume II: Habitat," Technical Report EN-94/01, U.S. Army Engineer Research and Development Center, Champaign, IL. Texas Parks and Wildlife (TPW). (2001). "The Golden-cheeked Warbler and Black-capped Vireo biology and natural history," http://www.tpwd.state.tx.us/wma/wmarea/gcw_bcv.htm (4 April 2001).

Travis Audubon Society. 2001a. "Endangered songbirds: Black-capped Vireo (Vireo atricapillus)," http://www.travisaudubon.org/Endanger/spp-bcv.htm (29 Oct 2001).

Travis Audubon Society. 2001b. "News: Endangered songbirds thrive at Lerr Wildlife Management Area," http://www.travisaudubon.org/News/a-kerrwma.htm (29 Oct 2001).

Travis Audubon Society.(2001c. "Endangered songbirds: Golden-cheeked warbler (Dendroica chrysoparia)," http://www.travisaudubon.org/Endanger/spp-gcw.htm (29 Oct 2001).

Tveten, J. L. 1993. "The birds of Texas," Shearer Publishing, Fredricksburg, TX.

U.S. Army, Fort Hood, Directorate of Public Works (DPW). 2001. "Endangered Species," http://www.dpw.hood. army.mil/HTML/ENV/endangered.htm (4 April 2001).

U.S. Fish and Wildlife Service. 1986. "Endangered and threatened wildlife and plants; proposal to determine the black-capped vireo to be an endangered species," Federal Register 51, 44808-44812. .

U.S. Fish and Wildlife Service. 1987. "Endangered and threatened wildlife and plants; determination of the black-capped vireo to be an endangered species," Federal Register 52, 37420-37423. .

U.S. Fish and Wildlife Service. 1990a. "Endangered and threatened wildlife and plants; emergency rule to list the Golden-cheeked Warbler as endangered," Federal Register 55, 1884-18845. .

U.S. Fish and Wildlife Service. 1990b. "Endangered and threatened wildlife and plants; proposed rule to list the Golden-cheeked Warbler as endangered," Federal Register 55, 18846-18849. .

U.S. Fish and Wildlife Service. 1990c. "Endangered and threatened wildlife and plants; final rule to list the Golden-cheeked Warbler as endangered," Federal Register 55, 53153-53160. .

U.S. Fish and Wildlife Service. 1991. "Black-capped Vireo (Vireo atricapillus) recovery plan," U.S. Fish and Wildlife Service, Austin, TX. .

U.S. Fish and Wildlife Service. 1992. "Golden-cheeked Warbler (Dendroica chrysoparia) recovery plan," U.S. Fish and Wildlife Service, Albuquerque, NM.

U.S. Geological Survey, Northern Prairie Wildlife Research Center. 2001. "Status of listed species and recovery plan development: Golden-cheeked Warbler (Dendroica chrysoparia) – Endangered," http://www.npwrc.usgs.gov/ resource/distr/others/recoprog/ states/species/dendchry.htm (6 April 2001).

Vidal, R. M., C. Macias-Caballero, and C. D. Duncan. 1994. The occurrence and ecology of the golden-cheeked warbler in the highlands of northern Chiapas, Mexico. Condor 96:684-91.

Wahl, R., D. D. Diamond, and D. Shaw. 1990. The Golden-cheeked Warbler: a status review. Ecological Services, U.S. Fish and Wildlife Service, Ft. Worth, Texas, USA.

Wauer, R. H. 1996. A field guide to the birds of the Big Bend, second edition. Gulf Publishing Co., Houston, Texas.

Wienberg, H. J., Hayden, T. J., and Cornelius, J. D. 1998. "Local and installation-wide Black-capped Vireo dynamics at the Fort Hood, Texas Military Reservation," Technical Report 98/54, U.S. Army Engineer Research and Development Center, Champaign, IL.

4 Species Profile for the Gray Bat

Gray Bat[1]

Myotis grisescens

Status

Endangered throughout its range (41 FR 17740, April 28, 1976).

Description

The largest member of its genus in the eastern United States, the gray bat weighs from 7 to 16 grams. Its forearm ranges from 40 to 46 millimeters in length (USFWS 1982). One feature that distinguishes this species from all other eastern bats is its unicolored dorsal fur. The other bats have bi- or tricolored fur on their backs. Also, the gray bat's wing membrane connects to the foot at the ankle instead of at the base of the first toe, as in other species of Myotis (USFWS 1982). For a short period after molt in July or August, gray bats are dark gray; but their fur usually bleaches to russet between molts. This difference in fur color is especially apparent in females during their reproductive season in May or June. Little is known about the actual feeding habits of gray bats. However, limited observations indicate that the majority of insects eaten are aquatic species, particularly mayflies.

Population

The gray bat population was estimated to be about 2.25 million in 1970; however, in 1976 a census of 22 important colonies in Alabama and Tennessee revealed an average decline of more than 50 percent (Tuttle, unpublished MS). Due to increases in protective measures at high priority colony sites in the late 1970s and throughout the 1980s, the declines have been arrested at some major sites and those populations are now stable or in some cases are increasing. The global abundance is estimated at 10,000 to >1,000,000 individuals.

[1] US FWS ES. Species Account: Gray Bat. http://www.fws.gov/endangered/i/a/saa4l.html (Accessed June 16, 2006). NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer . (Accessed: June 21, 2006).

The total population was estimated at 1.5 million in the early 1980s. About 10,000 can be found in Florida during the summer, a few hundred in winter (in Humphry 1992). Five gated maternity caves in Oklahoma each include 10,000 or 20,000 bats (Hensley 2003).

Distribution

Populations of the gray bat are found mainly in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee, but a few occur in northwestern Florida, western Georgia, southwestern Kansas, southern Indiana, southern and southwestern Illinois, northeastern Oklahoma, northeastern Mississippi, western Virginia, and possibly western North Carolina (Figure 4-1). Distribution within the range was always patchy, but fragmentation and isolation of populations have been a problem over the past 3 decades.

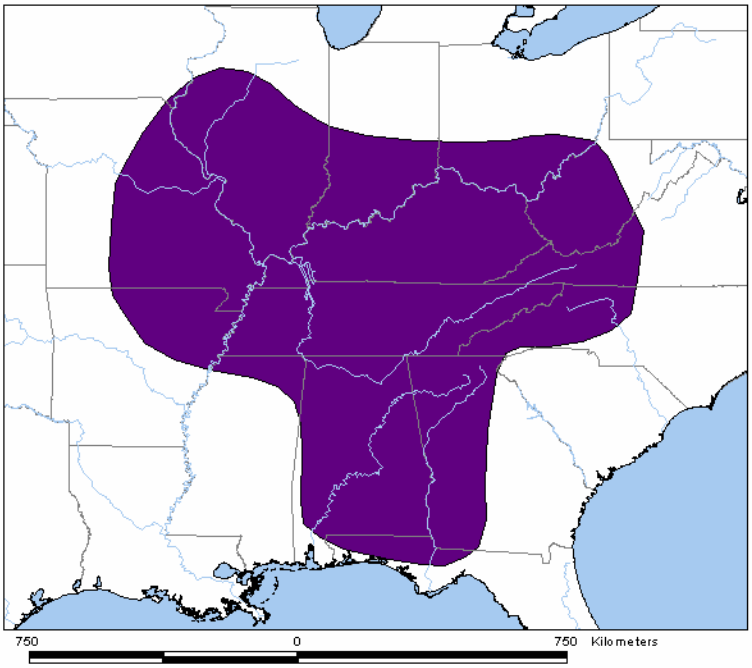

Figure 4-1. Distribution map of the gray bat.
The shaded area represents the range in which the gray bat resides permanently (NatureServe 2005).

Habitat

Gray bat colonies are restricted entirely to caves or cave-like habitats. During summer the bats are highly selective for caves providing specific temperature and roost conditions. Usually these caves are all located within 1

kilometer of a river or reservoir. In winter they utilize only deep, vertical caves having a temperature of 6 to 11 degrees Centigrade. Consequently, only a small proportion of the caves in any area is or can be used regularly. There are nine known caves that are believed to house roughly 95 percent of the hibernating population.

One-way migrating distance between winter and summer caves may vary from as little as 16 km to well over 322 km. Banding studies indicate the bats occupy a rather definite summer range with relation to the roosting site and nearby foraging areas over large streams and reservoirs. Summer colonies show a preference for caves not over 1.9 km from the feeding area.

Roosting Habitats: Unlike the related Indiana bat, the gray bat lives in caves (or cave-like places) year-round (Tuttle 1979a,b) and is probably more restricted to cave habitats than any other mammal native to the United States (Hall and Wilson 1966, Barbour and Davis 1969, Tuttle 1976a). A much wider variety of cave types is used during the spring and fall transient periods than during winter and summer (Brady et al. 1982). At all seasons, males and yearling females seem less restricted than reproductive females to specific cave and roost types (Tuttle 1976a). Because of highly specific roost and habitat requirements, fewer than 5 percent of available caves are suitable for occupation by gray bats (Tuttle 1979a,b). In accordance with Dwyer's (1971) general prediction, few caves in the northeastern United States are warm enough for rearing young, and few in the Southeast are cold enough for successful hibernation (Tuttle 1976a). Caves used by the gray bat must have temperatures appropriate for necessary metabolic processes; i.e., warm caves for digestion and growth in summer and cool caves for torpor and hibernation in fall and winter (Twente 1955).

Winter caves. Most winter caves are deep and vertical (Brady et al. 1982). They provide large volume below the lowest entrance and function as cold-air traps with multiple entrances and good air flow (Tuttle and Stevenson 1977b8). Winter caves average 10 °C below the mean annual surface temperature, and preferred temperatures range from 6 to 9 °C. Hall and Wilson (1966) found that temperatures were 10 to 11 °C at winter roosts in Kentucky, and Myers (1964) reported a mean temperature of 8.7 °C for winter caves in Missouri. These caves are already cold when gray bats arrive in September (USFWS 1980). In the military installation context, no important winter caves (hibernacula) are located on Army lands.

Summer caves. On the summer home range, colony members disperse in groups among several different caves (Tuttle 1976a). Reproductive females form maternity colonies of a few hundred to many thousands of individuals, while males and nonreproductive females congregate in smaller bachelor colonies (Harvey 1992). Only females and their young occupy the maternity cave, while the other groups use more peripheral caves within the area (Tuttle 1976a). After the young are volant, gray bats are more transient within the colony home range and frequently use alternate roost sites (Thomas 1994). Colonies select summer caves with temperatures that range from 14 to 25 °C (Brady et al. 1982). The maternity cave is usually the warmest one in the summer home range (Tuttle 1976a). Tuttle (1975) demonstrated that growth and development of the young are influenced by ambient temperature of the maternity cave; nonvolant young reared at 16 °C reached flight age 9 days earlier than those reared at 14 °C, and weight gain was even faster in warmer sites. Nursery populations succeed because gray bat maternity caves contain structural heat traps that capture the metabolic heat from a large number of clustered individuals (Tuttle 1976a). Maternity colonies prefer roost caves that are able to trap body heat from thousands of bats (Tuttle 1975, Tuttle and Stevenson 1977b). Typical cave configurations that trap heat include small chambers (Dwyer 1963), high places in domed ceilings (Davis et al. 1962), domes or small pockets within these locations (Dwyer 1963, Dwyer and Hamilton-Smith 1965, Dwyer and Harris 1972), and depth of etching and porosity of the rock surface (Tuttle 1975). Tuttle (1975) found that growth rates of nonvolant young are positively affected by the presence of porous or domed ceilings at roosts. Many Army installations located on or near karst limestone substrate have numerous caves and sinkholes that may support summer colonies, although no systematic census has been taken.

Artificial roosts. A few gray bat colonies roost at artificial (man-made) sites that simulate summer caves (Hays and Bingham 1964, Gunier and Elder 1971, Elder and Gunier 1978, Timmerman and McDaniel 1992). Storm drains have been used by gray bats in Kansas (Hays and Bingham 1964), Illinois (Elder and Gunier 1978), and Arkansas (Timmerman and McDaniel 1992). These storm drains have high humidity and running water without sewage; typical characteristics of natural caves. A small nursery colony of 200 bats roosting in a storm sewer in Pittsburg, KS, in the early 1960s (Hays and Bingham 1964), had grown to a population of 8,000 bats by 1971 (Gunier and Elder 1971). This population remained stable during the early 1970s but had decreased by 20 percent in the late 1970s

(Phillips and Hays 1978). The colony located in Newark, AR, was estimated at 8,000 bats in 1988 and appeared to be stable in the early 1990s (Timmerman and McDaniel 1992). A large nursery colony was also found in an abandoned barn in Missouri (Gunier and Elder 1971). They have also been reported to roost under concrete-formed bridges, where similar dark, moist conditions are maintained.

Foraging habitat: The gray bat appears to be restricted by its dependence upon major areas of water, because a direct correlation exists between the distribution of summer colonies and bodies of water (Tuttle 1976b). Gray bats forage primarily overwater along rivers or lake shores where flying insects are abundant (Tuttle 1976b, 1979; LaVal et al. 1977). In Tennessee, they use lakes and rivers and rely heavily on reservoirs (Tuttle 1976b); whereas in eastern Missouri, they forage over swift rivers, secluded streams, and the associated riparian vegetation (LaVal et al. 1977).

Much of the foraging habitat used by gray bats in their primary population centers (southern Appalachian and Ozark regions) has not been seriously modified by man's activities except for the construction of reservoirs (Brady et al. 1982). Much of the land in these regions is still forested and water quality is generally adequate for the production of aquatic insects. In some areas, reservoirs provide foraging habitat for gray bats. However, substantial areas of habitat have been altered by clearing, channelization, siltation, and herbicide application. Foraging habitat associated with summer roost caves still needs protection, maintenance, and in some cases, restoration.

It is essential to maintain and restore the habitat associated with foraging activities (Brady et al. 1982). Water quality of foraging areas and surrounding forest cover should be preserved. Any activities that might adversely affect foraging habitat within 25 km of major gray bat caves should be carefully evaluated and modified to protect the habitat. For example, forested corridors, river edges, and reservoir shorelines should be left intact near summer caves, and the vegetation surrounding cave entrances should be maintained to provide protection from predators during nocturnal emergence.

Summer colonies inhabit areas in which open water and the banks of streams, lakes, or reservoirs are within manageable distance of roosting sites and suitable caves in which to rear young (LaVal et al. 1976, 1977;

Tuttle 1976b). Gray bats often follow corridors of trees from roosts to feeding sites (LaVal et al. 1977). LaVal et al. (1977) found that bats flew downstream more often than upstream, suggesting a preference for the wider downstream sections of streams as opposed to narrower, upstream portions. Netting indicated that gray bats used even the smallest of permanently flowing streams, but greater numbers used the larger streams. Gray bats were distributed along 17 km of the river upstream and downstream from the roost cave, with a mean distance of 11.1 km and a range of 2 to 27.8 km from the roosting cave.

Summer colonies, especially maternity colonies, prefer caves that are within 1 km of a major river or lake and are rarely found in caves located at distances greater than 4 km (Tuttle 1976b). Factors closely correlated with distance traveled to feeding areas include growth rate and survival, condition of young, and adult mortality. For newly volant young, growth rates and survival are inversely proportional to the distance from the roost to the nearest overwater foraging habitat. Quality of foraging area, climatic conditions, and cave temperature are potential factors that influence growth and survival, but these become less significant when the distance from roosts to water becomes excessive. Forested areas surrounding caves or located between caves and feeding habitat are highly advantageous to gray bat survival (Tuttle 1979a). Newly volant young often feed and take shelter in forests surrounding cave entrances, and whenever possible, adult bats travel in the forest canopy between caves and foraging areas (Brady et al. 1982).

Threats and Reasons for Current Status

Gray bat colonies roost only in caves and cave-like habitats. Human disturbance and vandalism may have been primarily responsible for the decline. Disturbance of a maternity colony may cause thousands of young to be dropped to the cave floor where they perish; excessive disturbance may cause a colony to completely abandon a cave. Other factors that contributed to the decline included pesticide poisoning, natural calamities such as flooding and cave-ins, loss of caves due to inundation by man-made impoundments, and possibly a reduction in insect prey over streams that have been degraded through excessive pollution and siltation. Improper cave gating or cave commercialization have also contributed to some population declines.

Because human disturbance has made such an overwhelming contribution to the decline of gray bat populations, the impact of environmental disturbances has not been extensively studied nor clearly defined. However, certain environmental changes produce adverse effects on gray bat populations. The most outstanding impacts probably result from deforestation, chemical contamination, and impoundment of waterways.

Deforestation: Deforestation near cave entrances and between caves and rivers or reservoirs may cause adverse effects to bat populations (Tuttle 1979a,b). Tree canopy is especially important to gray bats in the vicinity of roost caves and along corridors to foraging areas. During evening emergence, gray bats usually fly to their feeding areas in the protection of forest canopy (Tuttle 1976a) and frequently travel out of their way to take advantage of scattered trees along a fence row (Tuttle 1979a,b). Tuttle (1979a) has observed that bats will limit foraging to the forested areas near roost caves in extremely cold spring weather. Deforestation and brush clearing near cave entrances increase gray bat susceptibility to predation. Screech owls, a common predator of gray bats, have much greater difficulty capturing bats in forest canopy, and the newly volant young receive greater protection in forest cover. The young are slow, clumsy fliers during the first week of flight and often spend several nights foraging in the forested area around the nursery cave before venturing farther away. Trees also provide protection from wind and convenient resting places for weak fliers.

Chemical contamination: Clark et al. (1978) documented mortality in gray bats and probable population decline resulting from routine insecticide use; unusually high levels of residues from heavily used insecticides were found in guano samples from bat caves. Mayflies, a major dietary item of gray bats, are sensitive to aquatic pollution (Tuttle 1976b) and have become rare in many foraging areas where they were once abundant (Fremling 1968). Declines of these and other insects eliminated by insecticides could prove disastrous for insectivore populations (Tuttle 1979a, b).

Impoundment of waterways: The preference of gray bats for caves near rivers has made caves particularly vulnerable to inundation by man-made impoundments (Tuttle 1979a). The initial effect of long-established impoundments, such as those in the Tennessee Valley Authority, is difficult to evaluate because of the lack of pre-impoundment data; however, available information indicates that many important caves were inundated, and bat populations were probably extirpated. M'Murtrie (1874)

described a heavily used bat cave in Alabama that was later flooded by a reservoir, and Tuttle (1979a) received accounts from longtime residents in Alabama and Tennessee about other bat caves that became submerged when waterways were impounded. A colony may survive if timing of initial flooding is offset from the use of caves; however, strong roost site fidelity may render survival of a displaced population questionable, even if it escapes initial destruction (Tuttle 1979a). The presence of reservoirs in gray bat home range can also be detrimental because increased numbers of people visiting reservoirs for recreational purposes can disturb quality foraging habitat.

Other Information

Reproduction and Development: Upon arrival at their wintering caves in early fall, the mature females enter estrus and are inseminated by sexually active males. The offspring, one per female, are born the following June when the colonies have migrated to their summer range. The period from birth to weaning covers about 2 months. During this time the colonies are usually segregated into maternity caves, where the young are reared, and into bachelor caves which house the adult males and yearlings of both sexes. By August, all of the juveniles are flying and there is a general mixing and dispersal of the colony over the summer range. Fall migration begins around the first of September and is generally complete by early November.

Grey Bat Counting and Trend Analysis: A series of papers regarding monitoring trends in bat populations was recently published as a U.S. Geological Survey Information and Technology Report (O'Shea and Bogan 2003). The report resulted from a workshop that included participation from leading experts in sampling and analysis of wildlife populations and gray bat biology and conservation. Information from the report relevant to the status of gray bat populations is summarized in the following paragraphs.

Tuttle (2003) stated that population monitoring was relatively straightforward for gray bats because they typically concentrate in relatively conspicuous groups of tens of thousand individuals that live year round in caves along waterways. Although estimating their exact numbers remains difficult, they aggregate in predictable fashion at specific summer nursery roosts, where they stain ceilings and leave large guano deposits that allow relatively consistent population estimates. However, Tuttle (2003) ex-

plained that many bats that hibernate in known caves may also use other locations unknown to humans. Also, counts may be difficult because bats form clusters of varied density, often high above the cave floor, which forces observers to estimate numbers based on knowledge of normal clustering behaviors and densities for each species. Tuttle (2003) emphasized that the most reliable means of determining roosting density is to construct a sturdy frame that encloses a specific area within which all bats can be counted (Tuttle 1975, Thomas and LaVal 1988). He further stated that while conducting winter surveys, all assumptions made regarding clustering densities and areas covered by bats should be recorded for each roosting area. Additionally, where assumptions or estimates are made without actual measurements, they should be made and recorded independently by at least two individuals (Tuttle 2003).

Kunz (2003) noted the following methods historically used for censusing bats: roost counts, evening emergence counts, evening dispersal counts, and disturbance counts. A combination of traditional census methods and recently developed remote censusing techniques was suggested to offer the greatest promise for estimating population sizes of most species. Thermal infrared (TIR) imaging was discussed as a promising technique for censusing bats as they emerge from roosts. An advantage stated for TIF imaging was that individuals can be censused independent of the ambient light at the time of emergence. However, successful application of the method requires a uniform background behind the bats so that this background can be digitally subtracted from the images of emerging bats (Kunz 2003). The TIR imaging process for bat surveys is described in Sabol and Hudson (1995). Kunz (2003) stated that censusing hibernating bats is best achieved by counting each individual bat or group of bats as they are encountered, or by estimating the mean density of bats in several representative clusters, and extrapolating the density to the total area of the cave wall or ceiling that is covered by bats. Surveys of hibernating bat should be limited to one census period every other year (Kunz 2003).

Ellison et al. (2004) compiled 1,879 observations of gray bats gathered from 334 roost locations through the species range. The majority of observations were collected from Missouri (735), Arkansas (377), Alabama (273), and Kentucky (194). Counts included maternity colonies (866), transient roosts (301), hibernacula (196), and bachelor colonies (101). Thirty percent of the observations were made after 1990. Information was analyzed from counts at 103 summer colonies and 12 hibernacula in Ala-

bama, Arkansas, Florida, Illinois, Kansas, Kentucky, Missouri, and Tennessee. The majority of the data from summer colonies showed no trend; 9 indicated an upward trend, and 6 indicated a downward trend. Also no trends were detected for 7 of the 12 hibernating colonies; 3 showed an upward trend and 2 a downward trend. Few data were said to be available for gray bat hibernation sites because of their sensitivity to disturbance. Even though this compilation of data from various sites did not show an obvious trend in bat populations, Ellison et al. (2003) stated that recovery efforts by the USFWS and others have suggested that gray bat numbers have rebounded in recent years. At the time the Recovery Plan was written, the gray bat population was thought to be approximately 1,575,000 across its range. In 2002, the total population was estimated to be 2,678,137, an increase of 61.5 percent from the time the plan was written (Ellison et al. 2004).

Army Installations Concerned

The following Army installations reported in the 2000 survey that the gray bat was found on their property: Charlestown, Indiana AAP; Camp Crowder, Neosho, MO; Fort McClellan, AL ; W.H. Ford Regional Training Center, Fort Campbell, KY; Fort Knox; KY; Fort Leonard Wood, MO.

The following installations report that the gray bat is known to be found on property contiguous to their lands: Fort Rucker, AL ,and Tullahoma Training Site, TN.

Management and Protection

Blowing Wind Cave in northern Alabama, the most important summer cave known for gray bats, has been acquired by the U.S. Fish and Wildlife Service and a gate has been placed across the entrance. Fern Cave, the largest known gray bat hibernaculum, has also been purchased by the Fish and Wildlife Service and is being managed for protection of the bats. Many other measures have been taken for protection of this species throughout its range. Some additional conservation measures needed include: (1) purchase and protection, through proper gating and restricted usage, of other gray bat caves; (2) education of spelunkers and other cave visitors who may unintentionally disturb the species; and, (3) continuation of federal efforts to reduce persistent pesticides in the environment.

Summary of the Recovery Plan for the Gray Bat

U.S. Fish and Wildlife Service, 1982[2]

Recovery Plan: The primary objective of the recovery plan is to move the gray bat from endangered to threatened status (Brady et al. 1982). The minimum requirements needed to achieve this goal are (a) documentation of protection of 90 percent of Priority 11 hibernacula, and (b) documentation of stable or increasing populations at 75 percent of Priority 1 maternity caves after a period of 5 years. The major recovery actions recommended by the USFWS are the (a) acquisition and protection of caves used by gray bats, (b) control of habitat destruction, and (c) education of the public.

Recovery Actions: The most important feature of the recovery plan is the protection of roosting habitat (Brady et al. 1982). This action has required gaining control of important gray bat caves to protect them from human disturbance, and the USFWS has purchased some important summer roost caves for this purpose. Signposting, gating, fencing, and surveillance by law enforcement agents have been used to protect caves. Major efforts have been made to gain the cooperation of landowners whose property contains historical or potential gray bat caves. Emphasis has been placed on protection during periods of cave residence, and efforts to eliminate disturbance have been concentrated from spring to late summer at maternity caves and from late summer to late spring at hibernacula.

Much of the foraging habitat used by gray bats in their primary population centers (southern Appalachian and Ozark regions) has not been seriously modified by man's activities except for the construction of reservoirs (Brady et al. 1982). Much of the land in these regions is still forested, and water quality is generally adequate for the production of aquatic insects. In some areas, reservoirs provide foraging habitat for gray bats. However, substantial areas of habitat have been altered by clearing, channelization, siltation, and herbicide application. Foraging habitat associated with summer roost caves still needs protection, maintenance, and in some cases, restoration.

[2] U.S. Fish and Wildlife Service. 1982. Gray Bat Recovery Plan. Prepared by the U.S. Fish and Wildlife Service in cooperation with the Gray Bat Recovery Team. Atlanta, Georgia. 91 pp.

Emphasis has been placed on educating government officials, landowners, and the general public regarding the ecological role of bats (Brady et al. 1982). Brochures and other literature have been made available to all of these groups throughout the range of the gray bat. Cave users (e.g., spelunkers) have been informed, and slide programs, interpretive signs at caves, and ranger-naturalist talks have helped to educate the public.

Military Installation Implications: If off-post special exercises are conducted in the vicinity of a roost cave used by gray bats, it could cause the bats to abandon the cave. As discussed above, colonies show strong loyalty to the home range (Tuttle 1976a), and cave abandonment could lead to the loss of an entire colony (Tuttle 1979a). So far as may be determined, no winter hibernacula are located on Army lands. Summer habitat is another matter entirely. Travel corridors to foraging areas can be degraded by actions such as deforestation or land clearing that increase bat susceptibility to predation (Tuttle 1979a). Pesticide use could affect the health of a gray bat colony (Clark et al. 1978), although it is unlikely that such a widespread use would be contemplated. All Federal agencies must consult with the USFWS about any planned activity on their lands that could adversely affect a colony of gray bats. Such activities on a military installation include training exercises, road construction, pesticide use, and land clearing in areas associated with roost caves and foraging sites. The major issue here would appear to be the lack of definitive population information as related to summer roosting and foraging areas.

References

References cited in this chapter and selected additional sources for more information.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. The University of Kentucky Press, Lexington, Kentucky.

Barbour, R.W. and W.H. Davis. 1974. Mammals of Kentucky. Univ. Kentucky Press, Lexington, KY. 322pp.

Brack, V., Jr., R. E. Mumford, and V. R. Holmes. 1984. The gray bat (MYOTIS GRISESCENS) in Indiana. American Midland Naturalist 111:205.

Brady, J., T. Kunz, M. D. Tuttle, and D. Wilson. 1982. Gray Bat Recovery Plan. U.S. Fish Wildlife Service 140 pp.

Caire, W., J. D. Tyler, B. P. Glass, and M. A. Mares. 1989. Mammals of Oklahoma. University of Oklahoma Press, Norman. Oklahoma. 567 pp.

Choate, J. R., J. K. Jones, Jr., and C. Jones. 1994. Handbook of mammals of the south-central states. Louisiana State University Press, Baton Rouge. 304 pp.

Clark, D. R., R. K. LaVal, and D. M. Swineford. 1978. Dieldren-induced mortality in an endangered species, the gray bat (MYOTIS GRISESCENS). Science 199:1357-9.

Clark, D. R., R. K. LaVal, and A. J. Krynitsky. 1980. Dieldrin and heptachlor residue in dead gray bats, Franklin County, Missouri, USA: 1976 vs 1977. Pesticide Monitoring Journal 13:137-40.

Clark, D. R., R. K. LaVal, and M. D. Tuttle. 1982. Estimating pesticide burdens of bats from guano analyses. Bull. Environ. Contam. Toxicol. 29:214-20.

Clawson, R. L., R. K. LaVal, M. L. LaVal, and W. Claire. 1980. Clustering behavior of hibernating MYOTIS SODALIS in Missouri, USA. Journal of Mammalogy 61:245-53.

Davis, R. B., C. F. Herreid II, and H. L. Short. 1962. Mexican free-tailed bats in Texas. Ecological Monographs 32:311-346.

Decher, J., and J. R. Choate. 1988. Critical habitat of the gray bat MYOTIS GRISESCENS in Kansas. (Abstract). Bat Research News 29(4):45.

Decher, J., and J. R. Choate. 1995. MYOTIS GRISESCENS. Mammalian Species (510):1-7.

Dwyer, P. D. 1963. The breeding biology of Miniopterus schreibersi blepotis (Temminck) (Chiroptera) in north-eastern New South Wales. Australian Journal of Zoology 11:219-240. 20 Species Profile: Gray Bat

Dwyer, P. D. 1971. Temperature regulation and cave-dwelling in bats: An evolutionary perspective. Mammal. 35:424-455.

Dwyer, P. D., and E. Hamilton-Smith. 1965. Breeding caves and maternity colonies of the bent-winged bat in south-eastern Australia. Helictite 4:3-21.

Dwyer, P. D., and J. A. Harris. 1972. Behavioral acclimatization to temperature by pregnant Miniopterus (Chiroptera). Physiological Zoology 45:14-21.

Eagar, D.C. and Hatcher, R.M. (editors). 1980. Tennessee's Rare Wildlife - Volume 1: The Vertebrates.

Elder, W. H., and W. J. Gunier. 1981. Dynamics of a gray bat population MYOTIS GRISESCENS in Missouri, USA. American Midland Naturalist 105:193-5.

Elder, W.H. and W.J. Gunier. 1978. Sex ratios and seasonal movements of gray bats (MYOTIS GRISESCENS) in southwestern Missouri and adjacent states. Amer. Midl. Nat. 99(2):463-472.

Ellison, L. E., M. B. Wunder, C. A. Jones, C. Mosch, K. W. Navo, K. Peckham, J. E. Burghardt, J. Annear, R. West, J. Siemers, R. A. Adams, and Erik Brekke. 2004. Colorado bat conservation plan: Colorado Committee of the Western Bat Working Group.

Fellers, G. M., and E. D. Pierson. 2002. Habitat use and foraging behavior of Townsend's Big-eared Bat (CORYNORHINUS TOWNSENDII) in coastal California. Journal of Mammalogy 83:167-177.

Figg, D. E. 1991. Missouri Department of Conservation Annual Nongame and Endangered Species Report July 1990 - June 1991. ii + 35 pp.

Figg, D. E. 1993. Missouri Department of Conservation wildlife diversity report, July 1992-June 1993. 75 pp.

Figg, D. E., and C. M. Bessken. 1995[?]. Missouri Department of Conservation wildlife diversity report: July 1994 - June 1995. v + 104 pp. [perhaps date is 1996]

Fremling, C. R. 1968. Documentation of a mass emergence of Hexagenia mayflies from the Upper Mississippi River. Trans. Amer. Fish Soc. 97:278-80.

Garner, J. D., and J. E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (MYOTIS SODALIS) in Illinois. Illinois Department of Conservation. Final Report, Project E-3. Springfield, IL, 23 pp.

Graves, F.F. and Harvey, M.J. 1974. Distribution of Chiroptera in western Tennessee. Journal of the Tennessee Academy of Sciences 49(3):

Griffin, D. R. 1940. Migrations of New England bats. Bulletin of the Museum of Comparative Zoology 86:217-246.

Gunier, W. J., and W. H. Elder. 1971. Experimental homing of gray bats to a maternity colony in a Missouri barn. Am. Midl. Nat. 86:502-6.

Gutherie, M. J., and K. R. Jeffers. 1938. A cytological study of the ovaries of the bats MYOTIS LUCIFUGUS and MYOTIS GRISESCENS. J. Morphol. 62:528-57.

Hall, E. Raymond. 1981. The Mammals of North America, Vols. I & II. John Wiley & Sons, New York, New York. 1181 pp.

Hall, J. S., and N. Wilson. 1966. Season population movements of the gray bat in the Kentucky area. American Midlands Naturalist 75:317-24.

Hamilton, W. J., Jr., and J. O. Whitaker, Jr. 1979. Mammals of the eastern United States. Cornell Univ. Press, Ithaca, New York. 346 pp.

Handley, C. O., Jr. 1991. Mammals. Pages 539-616 in K. Terwilliger, coordinator. Virginia's endangered species: proceedings of a symposium. McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Harvey, M. J. 1992. Bats of the eastern United States. Arkansas Game and Fish Commission, Little Rock.

Harvey, M. J. and V. R. McDaniel. 1988. Non-cave roosting sites of the endangered gray bat, MYOTIS GRISESCENS, in Arkansas. (Abstract). Bat Research News 29(4):47.

Harvey, Michael J., J. Scott Altenbach and Troy L. Best, 1999. Bats of the United States. Arkansas Game & Fish Commission and U.S. Fish and Wildlife Service, 64 pp.

Hays, H. A., and D. C. Bingham. 1964. A colony of gray bats in southeastern Kansas. Journal of Mammalogy 45:150.

Hensley, S. 2003. The treasures of the Ozark Plateau. Endangered Species Bulletin 28(1):32-33.

Herkert, J. R., editor. 1992. Endangered and threatened species of Illinois: status and distribution. Vol. 2: Animals. Illinois Endangered Species Protection Board. iv + 142 pp.

Herreid, C. F. 1963. Temperature regulation of Mexican free-tailed bats in cave habitats. Journal of Mammalogy 44:560-73.

Herreid, C. F. 1967. Temperature regulation, temperature preferene and tolerance, and metabolism of young and adult free-tailed bats. Physio. Zool. 40:1-22.

Humphry, S. R. 1992. Rare and Endangered Biota of Florida, Volume 1: Mammals. Univ. Press of Florida, Gainesville.

Kerr, L. R. 1973. Bat utilization of Limestone Mine Cave and Twin Culvert Cave in Pike County, Illinois. M.S. thesis. Western Ill. Univ., Macomb, IL. 66pp.

Kunz, T.H. 2003. Censusing bats: challenges, solutions, and sampling biases. Pp. 9-20, In: Monitoring Trends in Bat Populations of the United States and Territories: Problems and Prospects (T.J. O'Shea and M.A. Bogan, eds.). U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR-2003-003. Sciences Division, Information and Technology Report, Washington, D.C.

LaVal, R. K., R. L. Clawson, W. Caire, L. R. Wingate, and M. L. LaVal. 1976. An evaluation of the status of myotine bats in the proposed Meramec and Union Lake project areas, Missouri. School of Forestry, Fish, and Wildlife, University of Missouri, Columbia.

LaVal, R. K., R. L. Clawson, M. L. LaVal, and W. Caire. 1977. Foraging behavior and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species Myotis grisescens and Myotis sodalis. J. Mamm. 58:592-599.

Lacki, M. J., L. S. Burford, and J. O. Whitaker, Jr. 1995. Food habits of gray bats in Kentucky. Journal of Mammalogy 76:1256-1259.

Layne, J. N., editor. 1978. Rare and endangered biota of Florida. Vol. 1. Mammals. State of Florida Game and Freshwater Fish Commission. xx + 52 pp.

Lewis, Julian J. 1996. Inventory of the Subterranean Biota Threatened by the Urbanization of Clark and Floyd Counties, Indiana. Final Report to Indiana Department of Natural Resources, Division of Fish and Wildlife, Non-game and Endangered Wildlife Program. 71 pp.

Linzey, D. W. 1998. The mammals of Virginia. McDonald and Woodward, Blacksburg, VA. 459pp.

Lowe, D. W. 1990. Gray bat, MYOTIS GRISESCENS. Pages 503-505 in J. R. Matthews and C. J. Moseley, editors. The official World Wildlife Fund guide to endangered species of North America.

M'Murtrie, W. 1974. "Bat-excrement," American Chemist March, 339.

Matthews, J. R., and C. J. Moseley (editors). 1990. The Official World Wildlife Fund Guide to Endangered Species of North America. Volume 1. Plants, Mammals. xxiii + pp 1-560 + 33 pp. appendix + 6 pp. glossary + 16 pp. index. Volume 2. Birds, Reptiles, Amphibians, Fishes, Mussels, Crustaceans, Snails, Insects, and Arachnids. xiii + pp. 561-1180. Beacham Publications, Inc., Washington, D.C.

Menzel, M. A., R. Odom, S. Owen, W. M. Ford, B. R. Chapman, K. V. Miller, J. Edwards, and P. Wood. 1999. Investigation of foraging habitat use by bats with a focus on Northern Long-eared Myotis (MYOTIS SEPTENTRIONALIS): a comparison of methods. IN M. K. Clark, editor. Abstracts from the 1999 Colloquium on the conservation of mammals in the Southeastern United States. Available at: http://www.batworkinggroups.org/sbdnnews.htm. Accessed 2001-06-12.

Myers, R. F. 1964. Ecology of three species of myotine bats in the Ozark Plateau. Ph.D. dissertation, University of Missouri, Columbia.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer . (Accessed: June 21, 2006).

Nowak, R. M. 1991. Walker's mammals of the world. Fifth edition. Vols. I and II. Johns Hopkins Univ. Press, Baltimore. 1629 pp.

O'Shea, T.J., and M.A. Bogan, (eds.). 2003. Monitoring trends in bat populations of the United States and territories: problems and prospects. Fort Collins, CO: U.S. Geological Survey. Information and Technology Report USGS/BRD/ITR--2003-0003. 274 p.

Phillips, K., and H. A. Hays. 1978. Report on the gray bats (Myotis grisescens) in the storm sewers of Pittsburg, Kansas. Transactions Kansas Academy of Science 81:90-91. (abstr.)

Ransome, R. 1990. The natural history of hibernating bats. Christopher Helm, London. xxi + 235 pp.

Sabol, B. M., and M. K. Hudson. 1995. Technique using thermal infrared-imaging for estimating populations of gray bats. Journal of Mammalogy 76:1242-1248.

Schwartz, C. W., and E. R. Schwartz. 1981. The wild mammals of Missouri. University of Missouri Press, Columbia. 356 pp.

Sealander, J. A. 1979. A guide to Arkansas mammals. River Road Press, Conway. 313 pp.

Skaggs, D.M. 1973. Occurrence of Vespertilionid bats in some natural and man-made caverns of west-central Illinois. M.S. thesis. Western Ill. Univ., Macomb, IL. 53pp.

Smith, P. W., and D. W. Parmalee. 1954. Notes on distribution and habits of some bats from Illinois. Trans. Kansas Acad. Sci. 57:200-5.

Stevenson, D. E., and M. D. Tuttle. 1981. Survivorship in the endangered gray bat (MYOTIS GRISESCENS). Journal of Mammalogy 62:244-57.

Stevenson, D.E. and Tuttle, M.D. 1981. Survivorship in the endangered gray bat, Myotis grisescens. Journal of Mammalogy 62(2);

Timmerman, L., and V. R. McDaniel. 1992. A maternity colony of gray bats in a noncave site. Arkansas Academy of Science 46:108-109.

Thom, R. H. 1981. Endangered and threatened mammals. Pages 59-69 in M. Bowles, editor. Endangered and threatened vertebrate animals and vascular plants of Illinois. Natural Land Institute, Rockford, Illinois.

Thomas, D. P. 1994. A radiotelemetric assessment of the foraging ecology of the gray bat (Myotis grisescens) at Guntersville Reservoir, Alabama. M.S. thesis, Auburn University, Alabama.

Thomas, D.W. and LaVal, R.K. (1988) Survey and census methods. In Kunz, T.H., ed. *Ecological and behavioral methods for the study of bats*, pp. 77–89. Smithsonian Institution Press, Washington, DC.

Tuttle, M. D. 1975. Population ecology of the gray bat (Myotis grisescens): factors influencing early growth and development. University of Kansas Museum of Natural History Occasional Papers (36):1-24.

Tuttle, M. D. 1976a. Population ecology of the gray bat (MYOTIS GRISESCENS): factors influencing growth and survival of newly volant young. Ecology 57:587-95.

Tuttle, M. D. 1976b. Population ecology of the gray bat (MYOTIS GRISESCENS): philopatry, timing, and patterns of movement, weight loss during migration, and seasonal adaptive strategies. University of Kansas Museum of Natural History Occasional Papers (54):1-38.

Tuttle, M. D. 1977. Gating as a means of protecting cave dwelling bats. Pages 77-82 in T. Aley and D. Rhodes, editors. National cave management symposium proceedings.

Tuttle, M. D. 1978. Gray bat (MYOTIS GRISESCENS). USFWS endangered species red book.

Tuttle, M. D. 1979a. Status, causes of decline, and management of endangered gray bats. Journal of Wildlife Management 43:1-17.

Tuttle, M. D. 1979b. Twilight for the gray bat. Nat. Parks Conserv. Mag. 53:12-15.

Tuttle, M. D. 1987. Endangered gray bat benefits from protection. Endangered Species Technical Bulletin 21(3):4-5.

Tuttle, M. D., and D. E. Stevenson. 1977a. An analysis of migration as a mortality factor in the gray bat based on public recoveries of banded bats. Am. Midl. Nat. 97:235-40.

Tuttle, M. D., and D. E. Stevenson. 1977b. Variation in the cave environment and its biological implications. Pages 108-21 in R. Zuber, editor. National cave management symposium proceedings.

Tuttle, M.D. 1976. Population ecology of the gray bat (MYOTIS GRISESCENS): factors influencing growth and survival of newly volant young. Ecology 57:587-595.

Tuttle, M.D. 1976. Population ecology of the gray bat (MYOTIS GRISESCENS): philopatry, timing, and patterns of movement, weight loss during migration, and seasonal adaptive strategies. Univ. Kansas Mus. Nat. Hist. Occas. Papers 54:1-38.

Tuttle, M.D. 1979. Status, causes of decline and management of endangered gray bats. J. Wild. Manage. 43(1):1-7.

Tuttle, M. D. 2003. Texas bats. Bat Conservation International, Inc., Austin.

Twente, J. W., Jr. 1955. Some aspects of habitat selection and other behavior of caverndwelling bats. Ecology 36:706-732.

U.S. Fish and Wildlife Service (USFWS). 1980. Selected vertebrate endangered species of the seacoast of the United States - the gray bat. FWS/OBS-80/01.42, U.S. Fish and Wildlife Service, Slidell, LA.

USFWS. 1982. Gray Bat Recovery Plan. Prepared by the U.S. Fish and Wildlife Service in cooperation with the Gray Bat Recovery Team. Atlanta, Georgia. 91 pp.

USFWS. 1990. Endangered and threatened species recovery program: report to Congress. 406 pp.

USFWS-ES. Species Account: Gray Bat. http://www.fws.gov/endangered/i/a/saa4l.html (Accessed June 16, 2006).

Watland, A., J. Bak, S. Sekscienski, and B.Woodson. 2002. Installation Summaries From the 2001 Survey of Threatened and Endangered Species. SFIM-AEC-CD-TR-2002034 U. S. Army Environmental Center 5179 Hoadley Road, Bldg E4435 Aberdeen Proving Ground, MD 21010-5401.

Whitaker, J.O., Jr. 1975. Bats of the caves and mines of the Shawnee National Forest of southern Illinois, with particular emphasis on MYOTIS SODALIS, the Indiana bat. Pp. 25-64 in Distributional studies of the Indiana bat (MYOTIS SODALIS) on three National Forests of the Eastern Region. U.S. Dept. Ag., Forest Serv. Eastern Region, Milwaukee, WI. 64pp.

Whitaker, John O., L. Pruitt and S. Pruitt. 2001. The Gray Bat, Myotis grisescens, in Indiana. Proceedings of the Indiana Academy of Science. 110:114-122.

White, D. H., and J. T. Seginak. 1987. Cave gate designs for use in protecting endangered bats. Wildlife Society Bull. 15:445-449.

Wilson, D. E., and D. M. Reeder (editors). 1993. Mammal Species of the World: a Taxonomic and Geographic Reference. Second Edition. Smithsonian Institution Press, Washington, DC. xviii + 1206 pp. Available online at: http://www.nmnh.si.edu/msw/.

5 Species Profile for the Gopher Tortoise

Gopher Tortoise[1]

Gopherus polyphemus

Status

The gopher tortoise is threatened in Louisiana, Mississippi, and west of the Tombigbee and Mobile Rivers in Alabama (USFWS, 1987b). Larger populations, which are not federally listed, are found in eastern Alabama, Georgia, and throughout Florida. A very few smaller populations are found in South Carolina.

Status Summary: The present distribution of the gopher tortoise is much restricted as compared to the presettlement numbers. It is found essentially throughout Florida in suitable habitats. Present distribution in Alabama and Georgia is shown in Figure 5-1 and Figure 5-2. The federally listed population is represented by the four Alabama counties along the western border of the state. The other Alabama counties and the entire distribution in Georgia are without federally recognized status. Their Alabama designation is as a game animal with no open season. In Georgia, it is a state-listed threatened species, while Florida lists the tortoise as a Species of Special Concern, and requires scientific collection permits for collection and possession. Mississippi and South Carolina designate it "endangered." Although Louisiana affords the species no protection status, the Department of Wildlife and Fisheries is establishing an experimental population of gopher tortoises from confiscated and donated specimens on one of its wildlife management areas for research purposes and possible future relocation (Wahlquist 1991).

[1] NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 16, 2006). USFWS-ES. Species Account: Gopher Tortoise. http://www.fws.gov/endangered/i/c/sac2v.html (Accessed June 16, 2006).

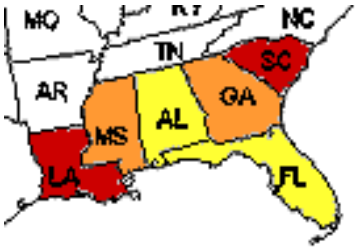

Figure 5-1. Status of the gopher tortoise.
Within the red states, the tortoise is critically imperiled, in the orange states the tortoise is imperiled, and in the yellow states, the tortoise is vulnerable (NatureServe 2006).

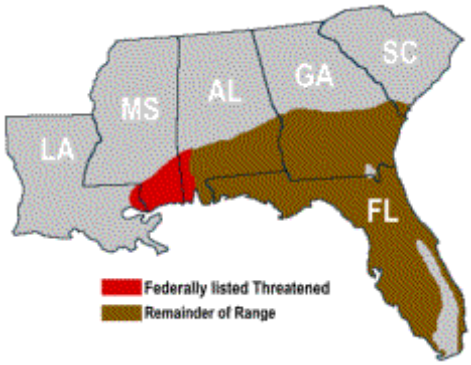

Figure 5-2. Distribution in the red is federally listed as threatened; the remainder of the range is colored brown.

Formerly common, the gopher tortoise has now been extirpated from parts of its range and many remaining populations are declining. Habitat destruction, habitat degradation through fire exclusion, and human predation have reduced the original number of tortoises by an estimated 80 percent over the past 100 years. A particularly unethical practice of "gassing" tortoise burrows to remove rattlesnakes is still legally allowed in Georgia, taking an unknown toll of gopher tortoises and inquilines. This wanton practice can also lead to the destruction of the burrow and refuge for the inquilines. In South Carolina, disjunct populations (estimated 200 to 2,000 individuals) exist in three counties. In recent years most of these populations have come under management by the SC Department of Natural Resources, and may be considered protected to some degree. In southern Georgia, which possibly contains the largest populations next to Florida, the tortoise still occurs on sand ridges in at least 81 counties.

Throughout the Georgia Coastal Plain, populations have been fragmented by urban and agricultural development and depleted by over-harvesting and habitat destruction. Vast tracts of gopher tortoise habitat are owned by the politically powerful forest products industry and associated private

pine plantation owners. In Florida, the gopher tortoise remains relatively widely distributed, occurring in all 67 counties (estimated population 1.2 million). However, on the average, 1,000 people take up residency in Florida weekly. Unregulated growth reigns supreme, particularly in the southern part of the state, which displaces gopher tortoises to peripheral habitat.

Gopher tortoises are still common in northern and central parts of peninsular Florida, but peripheral populations in the west and south have disappeared or are declining rapidly. Urban displacement, phosphate mining, and citrus production have had an impact on populations in central Florida. Human predation has depleted populations in the Florida Panhandle, and west Florida tortoise hunters now travel to Georgia and other states to illegally collect specimens. Tortoises occur in at least 21 counties in southern Alabama. Populations in that state appear to be recovering from past exploitation; however, exclusion of fire from upland habitats and creating corridors for highways and gas pipelines remain a problem for the species. Agricultural and forestry practices have had a severe impact on tortoise populations in their 14-county range in southern Mississippi. The largest remaining population occurs in the DeSoto National Forest, and includes major parts of Camp Shelby, MS, where the U.S. Forest Service and the Mississippi Army National Guard are making a conscientious effort to protect and manage the species. Gopher tortoises have apparently been a relictual species in Louisiana as in South Carolina. Pine plantations with emphasis on thickly planted stands of loblolly pine have contributed to the near extinction of tortoises in Louisiana (estimated native population of less than 100; Wahlquist 1991). More recently, the extensive blowdown of timber during Hurricane Katrina (September 2005) is expected to create many more open forests within the listed range. The actual effects are not known at this time.

Description

The gopher tortoise is a large (15 to 37 centimeters) brown to grayish-black terrestrial turtle. It has elephantine hind feet and shovel-like forefeet. The sex of individual turtles in the field is determined by shell dimensions and observation that male turtles have a greater lower shell concavity in addition to a longer gular projection. The sex of tortoises at mature size is sometimes difficult to determine beyond doubt in the field. The largest animals are usually presumed to be older females. The global abundance is estimated at 10,000 to >1,000,000 individuals.

The gopher tortoise is formerly common in upland ecosystems throughout the southeastern United States; it is now threatened with extirpation in many areas and in serious decline in others. There has been an approximately 80 percent decline in the number of gopher tortoises in the past 100 years (Auffenberg and Franz 1982). In 1982, the decline was predicted to continue to at least the year 2000. The January 2006 petition to list the Eastern population suggests that it has continued to the present (Save Our Big Scrub, etc).

Range: The gopher tortoise is found in six states in the southeastern United States. Other members of the genus are found in the Mojave Desert, Texas, and Mexico.

Distribution

The species occurs in sandy coastal plain areas from extreme southern South Carolina to the southeastern corner of Louisiana, and (originally) in every county in Florida (Figure 5-1). They also occur on coastal islands off Georgia and Florida. Most of its habitat is located on private lands with a very small percentage located on public, state, Federal, or military reserves. In this region, its distribution approximates the historical range of the longleaf pine, although many other pine species are now present in various locations. There is an indicated decline in population densities among these populations ranging from 67 percent in Alabama to 91 percent in Louisiana. The declines in the eastern populations are also estimated to be more than 50 percent throughout, and the tortoise has been eliminated from much of its former range, both east and west, for the reasons discussed below. The population segment from the Tombigbee and Mobile Rivers in Alabama, westward, is for convenience termed the western population (Figure 5-2).

Habitat

Gopher tortoises most commonly are found in upland areas that are characterized by a deep, well-drained, sandy substrate suitable for construction of their extensive burrows. In general, this must be at least 1 m (3+ ft) above the seasonal water table, but otherwise the tortoise shows no clear preference related to elevation. They appear to prefer relatively open-canopied habitats, generally less than 50 percent cover, where there are large, sunlit areas for nesting and thermoregulation, and reliable, low-level herbaceous ground cover for a food supply (Tuberville et al. 2007). While

the tortoise is most commonly associated with open pine woodlands, and often in habitats compatible with those where the red-cockaded woodpecker is managed, there is no inherent association with this habitat. Successful colonies, defined as groupings of 30 to 50 burrows within an area of 10 to 20 hectares (15 to 30 acres), may be found in many types of sparse broadleaf woodland, particularly scrub oaks of various species.

The development of gopher tortoise habitat begins with the evolution of sandhill ecosystems originating from marine sand deposits in the Plio-Pleistocene geological period from 5 to 15 million years ago. These coastal sands eventually mixed with soils to provide the growing base for arid-type plants that preferred sandy, well-drained soils. The primary plant community is composed of longleaf pine, turkey oaks, and wire grass. These plants are fire resistant, and in fact, the entire community is called a fire subclimax forest. Natural and man-induced burning on a regular cycle is essential to maintain the character of this habitat. Other prominent plants include lichens, yuccas, palmetto, shrubs, wildflowers, gopher apple, and prickly pear cactus (Wahlquist 1991).

Because the gopher tortoise is not reliably found above ground outside of its burrow, it is often necessary to use tortoise burrows as a means of assessing populations. Burrows within a defined area are designated a status or condition based on time since occupancy. The width of a burrow can be measured to estimate the size of the current resident tortoise. With these survey data, population counts and size class distributions can be determined for populations under study. The exact sampling techniques are far from standardized, and the relationship between the number of burrows and the number of tortoises is a matter of intense controversy, and appears to differ among different states and different sites within the state (Carthy et al. 2005).

Threats and Reasons for Current Status

Conversion of gopher tortoise habitat to urban areas, croplands, and pasturelands along with adverse forest management practices has reduced the western portion of the historic range of the gopher tortoise by more than 80 percent. Fragmentation of the western range accentuates those impacts. Taking gopher tortoises for sale or use as food or pets has also had a serious effect on some populations. Many species prey upon gopher tortoises including the raccoon, which is the primary egg and hatchling

predator; gray foxes; striped skunks; armadillos; dogs; snakes; and raptors. Imported red fire ants also have been known to prey on hatchlings.

In the eastern part of the range, there are many more tortoises surviving. At least partly because they are not federally listed, there is no even partially reliable count of numbers available, however it must be at least in the low hundreds of thousands. Even with these numbers, however, there is general agreement that drastic reduction in numbers has taken place in recent decades, with the causes being similar to the reasons for decline of the western population. The tortoise has some degree of state protection in each of the states in which it is found in the eastern population, though the nature of this status and the vigor with which protective measures are pursued differs widely among the states.

Historically, gopher tortoises were considered common in upland habitats throughout their range; however, this species now faces numerous threats to its continued survival in many areas. Overharvesting for food by humans, as well as habitat destruction, degradation, and fragmentation have contributed to the decline of this species. The gopher tortoise is long-lived with delayed sexual maturity and a low reproductive potential, therefore it is essential to develop management schemes that offer the tortoise adequate protection. Popular forest management practices that emphasize dense plantings of loblolly pine, destroy food plants, inhibit nesting, and cause tortoises to relocate to the edge of roadsides and ditch banks. Both the density of the original plantings, which provide little sunny habitat, and the typical final harvest practices, where all trees are removed, and the slash is windrowed and burned, followed by replanting of pine seedlings, create different types of unsatisfactory living conditions for the tortoise. The concentration of survivors along roadsides increases their susceptibility to human predation and vehicle mortality, which two factors may account for the loss of the species total annual recruitment, especially in the western population. “Protection” from fire in many areas, which results in the development of thick broadleaf underbrush, will also result in a continuing decrease in numbers.

Other Information

Importance to the Ecosystem: Perhaps the most important animal in this ecosystem is the gopher tortoise. Its presence is apparent from the burrows that it digs into sandy soils. Its burrow may be up to 10 feet deep and as much as 25 to 35 feet (diagonally) long, providing a well-insulated

refuge for the tortoise as well as 358 other species including 301 invertebrates and 57 vertebrate species. The creation of the burrow refuge has resulted in the gopher tortoise being acknowledged by ecologists as the keystone species for its habitat. The inquilines (co-inhabitants of the burrow), include the dung beetle which converts the dung into soil nutrients, the gopher frog which is found nowhere else but in burrows, various snakes such as the pine snake, coachwhip racer, red rat snake, gray rat snake, the eastern diamondback rattlesnake, and the threatened eastern indigo snake. Occupiers of abandoned burrows include the fox squirrel, opossum, raccoon, red and gray foxes, bobcats, armadillo, and bobwhite quail. Based on this extensive inventory, the gopher tortoise deserves the title of keystone species (Wahlquist 1991).

Reproduction and Development: Depending on the part of the range, at some time between April and July, the female digs a 15 to 20 cm (6 to8 in.) deep nest in sandy soil, lays a clutch of 4 to 12 eggs, and after refilling the hole leaves the eggs for incubation by the sun's heat. This clutch may be located almost anywhere with the home range of the female, but is commonly found relatively closer to her preferred burrow, so is not truly random. In habitats where the midstory or shrub layer has been allowed to become dense, the only open, sunny location may often be the apron of the burrow itself. This has led many observers to declare that this is the preferred location of the nest, which is probably a misstatement, though it is a common location.

Hatching takes place from August through September, again depending on the habitat, latitude, and other locational factors not well understood. The eggs, hatchlings, and juvenile tortoises suffer a heavy natural predation loss of almost 97 percent through the first 2 years of life. It is likely that there are many years in which no successful recruitment takes place. Those that survive grow to reproductive size and sexual maturity slowly, requiring from 13 to 21 years, depending on the portion of the range and the sex. Males may reach sexual maturity at a younger age and a smaller size than females. Females may not reach reproductive maturity until almost 20 years old in some populations. Further, it appears that not all females nest every year, accentuating the problem. The juveniles that hatch and survive may live, under ideal conditions, an average of 40 to 60 years, sometimes (possibly) 80 to 100.

Nest loss may reach 87 percent due to various predators including snakes and mammals. Based on burrow counts in northern Florida, it is estimated that from time of egg laying through the first year, the recruitment potential can be reduced by about 94 percent. Hatchlings will either dig their own miniature burrow or seek shelter opportunistically under sand, debris, or litter.

Gopher tortoise density and movements are affected by availability of forbs and grasses. The home range is inversely related to the amount of herbaceous grass cover. As the principal sandhill grazer, the gopher tortoise feeds primarily on grasses, succulent plants, and legumes. Legumes appear to be particularly important in the diet of juveniles. The gopher tortoise serves as a seed dispersal agent for native grasses and returns leached nutrients to the surface during burrow construction. In the military installation context, the question of an assured food supply may often be overlooked, and not well-managed in comparison to issues of burrow protection.

Most of the gopher tortoise's life is spent in and around the burrow. The gopher tortoise establishes a well-defined home range that increases in size as the tortoise grows older and larger. These ranges vary by the age and sex of the tortoises, with males having much greater ranges, on average, up to 10 hectares (25 acres) or more, at least on an annual basis. Females will typically have an annual range of one-third to one-half this area. For refuge the tortoises dig burrows that average around 1.5 to 3 m (5 to 10 ft) in depth and may be 3 to 6 m (10 to 20 ft) (or more) in length. The burrow becomes a more or less permanent home although there may be alternate burrows in the area. Season-long studies have shown that females may utilize three to five burrows at one time or another, while some males may utilize 10 or more during the season, and travel 1000 m or more from one to another in a single day.

Aggregations of burrows (and, therefore tortoises) may be referred to as a "colony." Current thought is that approximately 40 to 50 animals are required to comprise a reproductively functioning colony. We now know that tortoises in healthy populations maintain an active social interaction with their neighbors, visiting animals in nearby burrows on a more or less regular basis. These visits provide for both intra- and inter-sex meetings, with confrontation and mating a frequent result. Especially in the highly fragmented western population, there may be as few as 40 or 50 colonies that

so function. The remainder of the many thousands of tortoises in this area (Louisiana, Mississippi and westernmost Alabama) exist as isolated individuals or smaller groups. Several other species may also share gopher tortoise burrows. Some commonly known burrow associates include the eastern indigo snake, the eastern diamondback rattlesnake, and the gopher frog (USFWS 1990). The frequency with which these and other species utilize tortoise burrows (both active and abandoned) has led to the designation of the gopher tortoise as a keystone species.

Potential for Recovery: Forest and range management that promotes grassy, open canopy habitat is necessary. Recommended management in natural longleaf pine-scrub oak stands include thinning of dense oaks, reestablishment of the pine component (to aid in carrying fire) and prescribed burning at least every 5 to 10 years where summer burns are feasible or every 2 to 4 years if winter burns are used. In commercial pine plantations using low intensity site preparation, planting fire tolerant species at wide spacings, maximizing edge, and burning annually or biennially will benefit tortoise populations. Other suggested conservation measures include establishment of refuges, protection from over-harvest, restocking in unoccupied habitats, and public education. Captive propagation has been successful in many locations. Zoo Atlanta has been successful for several years in breeding its pair and rearing the juveniles. In some cases, juveniles have been returned to the wild. However, due to the recent discovery and outbreak of the respiratory disease syndrome in captive and wild tortoises, under no circumstances should tortoises be indiscriminately released without veterinary inspection and approval of the appropriate state or federal agency. Organized captive breeding programs are not required at this time.

Army Installations Concerned

Only Camp Shelby, MS, reported in the 2000 survey that the gopher tortoise was found on their property, and was a portion of the western, federally threatened, population. However, the tortoise is found on at least the following military installations elsewhere within its range, and is being studied due to its potential for causing training conflicts were it to be listed, as was requested by a Florida group in January 2006: Fort Rucker, AL, including several outlying landing fields; Fort Benning, GA; Fort Stewart, GA; Fort Gordon, GA; Camp Blanding, FL; and at least eleven other Navy, Marine Corps, and Air Force installations in Florida and Georgia.

Management and Protection

Less than 20 percent of the historically available habitat remains for the western population of the gopher tortoise. Protection of this habitat, along with proper management, deserves high priority. Since the gopher tortoise requires an open forest floor with grasses and forbs for food, and sunny areas, regular burning or thinning of trees is required to maintain this type of habitat. Taking gopher tortoises for sale or use as food or pets has also had a serious effect on some populations, and will require control through public education and effective enforcement of taking prohibitions under Section 9 of the Endangered Species Act.

Most tortoise habitat is on private land and most timberland owners still have problems with the growth, economic value, and availability of seed stock of longleaf. Proper longleaf forest management for on-site species, such as the gopher tortoise, should be encouraged on private and state lands. In relation to red-cockaded woodpecker management concerns, many military installations are replanting longleaf pine where loblolly and shortleaf plantations had been found for more than 50 years. If allowed to develop with an open understory as recommended for woodpecker management, this should prove highly suitable, in the long term, for the gopher tortoise as well.

The most significant threat is loss of habitat to intensive land use, particularly housing projects, industrial centers, corporate agriculture, and forestry, phosphate strip-mining, and sand extraction. Many of these factors are also present in the military installation context, with the addition of development of weapons ranges, which require massive earthmoving to provide sight lines and terrain backdrop for the direct-fire heavy weapons. As stated earlier, most of the land is in private ownership, with only a small percentage in military, federal, or state reserves.

As noted earlier, another factor of importance is the exclusion of fire from natural longleaf pine and scrub oak habitats, thanks to the “Smoky Bear” syndrome. An open canopy and relatively litter-free ground are necessary for food production and nesting, and such conditions are favored by regular burning. Tortoise numbers may be reduced by as much as 60 to 80 percent when burning is excluded for 8 or more years. The use of heavy machinery to reduce logging debris in preparation for planting pine trees is detrimental to gopher tortoises. However, studies in southern Georgia

and northern Florida demonstrated that gopher tortoises are able to dig out following chopping treatment on deep sandy soils.

The tortoise response to more intensive site preparation techniques may vary substantially. Increased urbanization in Florida (1,000 new residents per week) has focused attention on displacement of tortoises. Tortoise relocation is being advocated by developers and their environmental consultants, and by regional planning councils with little thought to such biological impacts as carrying capacity of relocation habitats, population disruptions, gene pool mixing, and parasite and disease transmission (Wahlquist 1991). This is also an issue with military installation relocation policies, most of which do not address any of these issues.

Given the low reproductive potential, this species is very susceptible to over-harvest. Exploited in Florida for over 4,000 years, the gopher tortoise was a major food source for many families during the Depression. Due to prohibition or regulation of harvest, diminished tortoise populations, and the increase of "posted" private lands, the practice of collecting gopher tortoises for consumption has declined. Some progressive state agencies have initiated law enforcement efforts to reduce illegal take. However, illegal commercialization still occurs in some areas. Although a one-time harvest is not necessarily the "death knell" for a colony, intensive predation pressure sustained over a long period could have a serious impact on local populations. Gopher tortoises are often considered pests on livestock ranges, and local hunters are sometimes enlisted to remove them. Other threats include mortality on highways and the collection of tortoises for pets or racing purposes. Irresponsible people vacationing in the South continue to pick up tortoises and bring them home as pets. They end up escaping or are dumped, walking the streets of Atlanta, Georgia; Nashville, Tennessee; Little Rock, Arkansas; or other unsuitable locations. Large-scale rattlesnake roundups and legalized "gassing" in Georgia, and the use of agricultural chemicals may also have deleterious effects on tortoise populations (Wahlquist 1991).

Gopher Tortoise Petition To List - January 2006

There was a petition in January 2006 by Save Our Big Scrub, Inc. (Save Our Big Scrub 2006) to list the eastern population of the gopher tortoise as a threatened species instead of endangered.

> Save Our Big Scrub, Inc. pursuant to Section 4(b)(3)(A) of the Endangered Species Act ("ESA"), 16 U.S.C. 1533(b)(3)(A), and the Administrative Procedure Act ("APA"), 5 U.S.C. 535(c), hereby petitions the Secretary of the United States Department of the Interior ("Secretary") and the Director of the United States Department of the Interior ("FWS") to formally list the eastern population of the gopher tortoise (Gopherus polyphemus), east of the Mobile and Tombigbee rivers in Alabama, Florida, Georgia and South Carolina, as a threatened species under the ESA and to designate critical habitat as required by Section 4(2), 16 U.S.C. 1522(b)(2). This may be expected to result in action by the FWS at some time in the future to examine the status of the eastern, presently unlisted, populations in order to respond to the petition. No specific determination has been made at this time as to candidate status or priority.

Military Installation Implications: Most of the private land threats to tortoise success appear to be present to some degree on military installations as well. They are summarized below.

Predation. Note that there are two major phases in predation: at the very juvenile and at maturity. The egg and juvenile predators, such as raccoons, foxes, skunks, coyotes, and other carnivores are as likely, or even more likely, to be present on military installations than on private lands. The red imported fire ant, *Solenopsis invicta*, has been reported to be a consumer of eggs and very small hatchlings. It is strongly suspected that, in at least some cases, ants have directly attacked an otherwise healthy hatchling (Epperson and Heise 2003). In other cases, it is not possible to determine if there was an existing wound or debilitating condition or if the ants are simply consuming the dead animal. Many areas within the tortoise range have a strong tradition of treating the tortoise as a food animal ... in fact, this surely predates European settlement. However, military lands that are effectively open to local collecting of tortoises for food, even though this is against law and regulation throughout the tortoise range, may seriously affect long-term population maintenance. Better enforcement of existing regulations against collection of tortoises outside of military bases is highly recommended.

Habitat Degradation. The most common form of habitat degradation on and off military installations is the prevention of regular ground fires. As noted in several places here, the tortoise requires sunny, open sites with a good growth of a variety of nutritious herbaceous plants. Lands where introduced pasture grasses predominate may provide adequate food only early in the season. Many common grasses do not provide adequate nutrition, especially when they are dry, as in their late summer and fall condition. Development of a deciduous mid-story cover is also very detrimental. In many such situations, one sees tortoises digging a series of burrows along the road shoulders, the only open, sunny areas available. Here they are susceptible to both the danger of passing vehicles and to increased human collection and predation, whether for food or pets.

Direct Injury. Aside from road hazards, tortoises appear to be fairly resistant to being accidentally run over while in their normal habitat. They are surely sensitive to vibration, and usually react to the approach of vehicles by entering a burrow. While in the burrow, they are relatively safe from many surface activities. Intentional deep digging, as for foundations, is one hazard against which they have no protection. Trapping, removal, and relocation of all animals in or near construction sites is required by regulation in Florida, and requires permits to do so. For the western (federally listed) population, any construction or forest management activities will require Section 7 consultation. The whole “art” of relocation is undergoing several research thrusts, including studies sponsored by the Army, to determine the best manner to implement the relocation. One major caveat relates to the disease status of the animals in question.

Disease. Some populations of gopher tortoises are now known to be infected with the organism *Mycoplasma agassizii*, the causative agent of Upper Respiratory Tract Disease (URTD) in the desert tortoise. In the desert tortoise it has largely been confirmed as the cause of decline in health and at least a contributor to death of individuals. It is strongly suspected to play a similar role in the gopher tortoise, although this has not been absolutely confirmed. In the military installation context, it appears that the major contributing factor may be the indiscriminate relocation of animals without concern for the URTD status. It has been verified that animals that appear healthy and show no overt symptoms of the disease may, in fact, show positive antibody titer for it. In turn, it is not clear if this means they are just developing the disease, if they have a non-lethal form of it, or if they have been infected but recovered. Further, it is not known if the

animals in this last group have developed resistance to reinfection. Studies sponsored by the Army are now underway which may determine some of these responses, at least of the populations on Fort Benning, GA.

Summary of the Gopher Tortoise Recovery Plan

U.S. Fish and Wildlife Service, 1990[2]

Recovery Objective: The two objectives of this plan consist of an immediate objective, which is prevention of the listed population from becoming endangered, and a long-term objective, which is delisting.

Recovery Criteria:

(1) Successful prevention of endangered status would be considered by evidence of an average of 5 gopher tortoise burrows per hectare (ha) on deep sandy soils (1.52 meters +) for a period of 30 years on the DeSoto National Forest. This would equate to an estimated population of 22,400 gopher tortoises on 7,343 ha of suitable habitat.

(2) For delisting, evidence is required of an average of 3 gopher tortoise burrows per ha on deep sandy soils (1.52 meters +) on private lands. This would equate to an estimated population of 34,000 gopher tortoises on 18,594 ha on privately-owned lands.

Actions Needed:

(1) Survey, monitor, and assess status of populations as baseline for recovery actions.

(2) Protect and manage habitat on Federal lands.

(3) Encourage management of populations on private lands.

(4) Develop law enforcement strategy to curb illegal taking.

(5) Conduct population viability studies.

(6) Conduct telemetry studies to determine extent of reproductive isolation as a threat.

(7) Conduct genetic studies.

[2] U.S. Fish and Wildlife Service. 1990. Agency Draft: Gopher Tortoise Recovery Plan. 37 pages. USFWS, Endangered Species Program, Southeastern Regional Office, Atlanta, Georgia.

(8) Relocate threatened isolated individuals/colonies to protected and managed lands.

References

References cited in this chapter and selected additional sources for more information.

Auffenberg, W., and J. B. Iverson. 1979. Demography of terrestrial turtles. Pp. 541-569 In Harless, M., and N. Norlock (eds.) Turtles: research and perspectives. Wiley-International, NY. 718pp.

Auffenburg, W. and R. Franz. 1982. The status and distribution of the Gopher Tortoise (Gopherus polyphemus). Pp. 95-126 In R.B. Bury (ed.). North American tortoises: conservation and ecology. Wildlife Research Report 12. U.S. Fish and Wildlife Service, Washington, D.C.

Bent, A.C. 1987. Life history of North American birds of prey, part 1. U.S. Government Printing Office, Washington D.C. 409pp.

Carthy, R., M.K. Oli, J.B. Wooding, J.E. Berish, and W.D. Meyer. 2005. Analysis of gopher tortoise population estimation techniques. Report to USACOE-CERL.

Cox, J.A. 1987. Status and distribution of the Florida scrub jay. Florida Ornithological Society Publication No. 3. 110pp.

Cox, J., D. Inkley, and R. Kautz. 1987. Ecology and habitat protection needs of gopher tortoise (Gopherus polyphemus) populations found on lands slated for large-scale development in Florida. Florida Game and Fresh Water Fish Commission. Nongame Wildlife Program Technical Report No. 4. Tallahassee, FL. 75pp.

Cox, J., R. Kautz, M. Maclaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and Fresh Water Fish Commission - Office of Environmental Services, Tallahassee, FL. 239pp.

Diemer, J.E. 1992. Gopher tortoise. Pp.123-127. In P.E. Moler (ed.), Rare and Endangered Biota of Florida. Amphibians and Reptiles. University Presses of Florida, Gainesville, FL.

Diemer, J.E. 1991. Identification of critical gopher tortoise habitat in South Florida. Final Report, Study Number: 7539, Study Period: 1 July 1990 - 30 June 1991. Florida Game and Fresh Water Fish Commission. Tallahassee, FL. 23pp.

Diemer, J. 1989. Gopherus polyphemus, Gopher tortoise. pp. 14-16. In: The Conservation Biology of Tortoises. IUCN Species Survival Commission. Occasional Paper No. 5.

Diemer, J.E. 1986. The ecology and management of the gopher tortoise in the southeastern U.S. in Herpetologica 42:125-133.

Diemer, J.E. 1987. The status of the Gopher Tortoise in Florida. Pp. 72-83. In R. Odom, K. Riddleberger and J. Ozier (eds.), Proceedings from the Third Southeast Nongame and Endangered Species Symposium. Georgia Department of Natural Resources Game and Fish Division. Atlanta, GA.

Epperson, D. M. and C. D. Heise. 2003. Nesting and Hatchling Ecology of Gopher Tortoises (Gopherus polyphemus) in Southern Mississippi. Journal of Herpetology 37:315-324

Ehrlich, P.R., D.S.Dobkin and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster, Inc. 785pp.

Fitzpatrick, J.W., G.E. Woolfenden, M.T. Kopeny. 1991. Ecology and development-related habitat requirements of the Florida scrub jay (Aphelocoma coerulescens coerulescens). Florida Game and Fresh Water Fish Commission. Nongame Wildlife Program Technical Report No. 8. Tallahassee, FL. 49 pp.

Florida Game and Fresh Water Fish Commission. 1991. Burrowing owl nest protection guidelines and procedures. October 7, 1991 Revision. Florida Game and Fresh Water Fish Commission. Tallahassee, FL. 1pp.

Florida Game and Fresh Water Fish Commission. 1991. The Florida scrub jay. Florida Game and Fresh Water Fish Commission - Office of Environmental Services and Office of Informational Services, Gainesville, FL. Brochure.

Florida Power & Light Company. 1989. Florida's wood storks. 26pp.

Florida Power & Light Company. 1992. The bald eagle in Florida. 38pp.

Godley, J.S. 1992. Gopher frog. Pp. 15-19. In P.E. Moler (ed.), Rare and Endangered Biota of Florida. Amphibians and Reptiles. University Presses of Florida, Gainesville, FL.

Gopher Tortoise Council. 1988. The gopher tortoise: A species in decline. Florida Museum of Natural History, University of Florida. Gainesville, FL. Brochure.

Humphrey, S.R. and P.G.R. Jodice. 1992. Big Cypress fox squirrel. Pp. 224-233. In S.R. Humphrey (ed.), Rare and Endangered Biota of Florida. Mammals. University Presses of Florida, Gainesville, FL.

Jackson, D.R. and E.G. Milstrey. 1989. The fauna of gopher tortoise burrows. Pages 86-98 in Diemer, J., D. Jackson, J. Landers, J. Layne and D. Wood (eds.). Proceedings: Gopher tortoise relocation symposium. Nongame Wildlife Program Technical Report No. 5. Florida Game and Fresh Water Fish Commission. Tallahassee, FL.

Jodice, P.G.R. 1993. Movement patterns of translocated Big Cypress fox squirrels (Sciurus niger avicennia). Florida Scientist 56:1-6.

Jodice, P.G.R. and S.R. Humphrey. 1992. Activity and diet of an urban population of Big Cypress fox squirrel. Journal of Wildlife Management 56:685-692.

Kale, H.W., II, B. Pranty, B. Stith and W. Biggs. 1992. An atlas of Florida's breeding birds. Final report. Nongame Wildlife Program, Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Kellert, S.R. 1979. Children's attitudes, knowledge, and behavior towards animals. Phase V Report on American Attitudes, Knowledge and Behavior Toward Wildlife and Natural Habitats. USDI, FWS, Washington, D.C. 20240.

Layne, J.N. and T.M. Steiner. 1984. Sexual dimorphism in occurrence of keeled dorsal scales in the Eastern Indigo (Drymarchon corais couperi). Copeia 1984(3):776-778.

Macdonald, L.A. and H.R. Mushinsky. 1988. Foraging ecology of the Gopher Tortoise, Gopherus polyphemus, in a sandhill habitat. Herpetologica 44:345-353.

Mendonca, M. and R. Beauman. 2006. Burrow collapse as a potential stressor on the Gopher tortoise. Technical Report for the US DoD, FWS, and ERDC-CERL Champaign, IL.

Moler, P.E. 1992. Eastern indigo snake. Pp. 181-186. In P.E. Moler (ed.), Rare and Endangered Biota of Florida. Amphibians and Reptiles. University of Florida Presses, Gainesville, FL.

Mushinsky, H.R. 1985. Fire and the Florida sandhill herpetofaunal community: with special attention to responses of Cneimidophorus sexlineatus. Herpetologica 41:33-342.

Mushinsky, H.R. and D.J. Gibson. 1991. The influence of fire periodicity of habitat structure. In S.S. Bell, E.D. McCoy, H.R. Mushinsky (eds.), Habitat structure: the arrangement of objects in space. Chapman and Hall. 464pp.

Myers, R.L. and J.J. Ewel (ed.). 1990. Ecosystems of Florida. University of Central Florida Press, Orlando, FL. 765pp.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 16, 2006).

Nesbitt, S.A. 1978. Limpkin. Pp. 86-88. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Nesbitt, S.A. 1995. Bald eagle population monitoring. Annual Performance Reports. Statewide Wildlife Research, Study No. 7521. Florida Game and Fresh Water Fish Commission. 7pp.

Ogden, J.C. 1978. Louisiana heron. Pp. 77-78. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Ogden, J.C. 1978. Snowy egret. Pp. 75-76. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Ogden, J.C. 1978. Wood stork. Pp. 3-4. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

O'Meara, T.E. and J.A. Gore. 1988. Guidelines for conservation and management of least tern colonies in Florida. Florida Game and Fresh Water Fish Commission. 12pp.

Owre, O.T. 1978. Florida burrowing owl. Pp. 97-99. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Polen, K.J. 1995 Collier County Listed Species Guide. Collier County Environmental Service Division Publication Series NR-SP-95-02.

Robertson, W.B., Jr. 1978. Roseate spoonbill. Pp. 52-53. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Robertson, W.B., Jr. 1978. Southern bald eagle. Pp. 27-30. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Rodgers, J.A., Jr. 1978. Little blue heron. Pp. 72-73. In H.W. Kale, II, (ed.), Rare and Endangered Biota of Florida. Birds. University Presses of Florida, Gainesville, FL.

Save Our Big Scrub, Inc. January 2006. Petition to list the Eastern population of the Gopher tortoise as a Threatened species. Sent to US Department of the Interior and Director of the US FWS.

Steiner, T.M., O.L. Bass, Jr. and J.A. Kushlan. 1983. Status of the Eastern Indigo Snake in southern Florida national parks and vicinity. Report SFRC-8 3/01, South Florida Research Center, Everglades National Park, Homestead, FL.

Stys, B. 1993. Ecology and habitat protection needs of the Southeastern American kestrel (Falco sparverius paulus) on large-scale development sites in Florida. Nongame Wildlife Technical Report No. 13. Tallahassee, FL. 35pp.

Stys, B. 1994. Ecology and habitat protection needs of Florida sandhill cranes on areas proposed for land conversion activities. Florida Game and Fresh Water Fish Commission. Nongame Wildlife Program Technical Report No. 14. Tallahassee, FL. 27pp.

Tuberville, T.D., K.A. Buhlmann, H.E. Balbach, S.H. Bennett, J.P. Nestor, J.W. Gibbons, and R.R. Sharitz. 2007. Habitat selection by the gopher tortoise (Gopherus polyphemus) ERDC-CERL Special Report (SR) 07-01. U.S. Army Construction Engineer Research Laboratory, Champaign, IL.

U.S. Fish and Wildlife Service (USFWS). 1986. Recovery plan for the U.S. breeding population of the wood stork. U.S. Fish and Wildlife Service, Atlanta, GA. 28pp.

USFWS. 1982. Eastern indigo snake recovery plan. U.S. Fish and Wildlife Service, Atlanta, GA. 23pp.

USFWS. 1987a. Habitat management guidelines for the bald eagle in the Southeast region. Third Revision. U.S. Fish and Wildlife Service, Atlanta, GA. 8pp.

USFWS. 1987b. Final rule: Threatened Status for the Gopher Tortoise. 43 Federal Register, 4 August 1987.

USFWS. 1990. Agency Draft: Gopher Tortoise Recovery Plan. 37 pages. USFWS, Endangered Species Program, Southeastern Regional Office, Atlanta, Georgia.

USFWS. 1989. Southeastern states bald eagle recovery plan.

USFWS, Atlanta GA. 41pp. + 79pp.

USFWS. 1990. Habitat management guidelines for the wood stork in the Southeast region. U.S. Fish and Wildlife Service, Atlanta, GA. 9pp.

USFWS-ES. Species Account: Gopher Tortoise. http://www.fws.gov/endangered/i/c/sac2v.html (Accessed June 16, 2006).

Wahlquist, Harold. 1991. Gopher Tortoise Conservation. in: Proc. 1st Intern. Symposium on Turtles and Tortoises: Conservation and Captive Husbandry. Pages 77-79.

Williams, K.S. and S.R. Humphrey. 1979. Distribution and status of the endangered big cypress fox squirrel (Sciurus niger avicennia) in Florida. Florida Scientist 42:201-205.

Wood, D. June 1994. Official lists of endangered and potentially endangered fauna and flora in Florida. Tallahassee, FL. 22pp.

Wood, P.B., D.A. Buehler and M.A. Byrd. 1990. Bald eagle. Pp. 13-21 in Proceedings of Southeast Raptor Management Symposium and Workshop. National Wildlife Federation, Washington, D.C.

Wood, P.B., T.C. Edwards, Jr. and M.W. Collopy. 1989. Characteristics of bald eagle nesting habitat in Florida. Journal of Wildlife Management 53:441-449.

Woolfenden, G.E. and J.W. Fitzpatrick. 1984. The Florida scrub jay: demography of a cooperative-breeding bird. Princeton University Press, Princeton, NJ. 406pp.

6 Species Profile for the Indiana Bat

Indiana Bat[1]

Myotis sodalis

Status

The Indiana bat is endangered throughout its range (52 FR 7426, March 11, 1967).

Description

The Indiana bat is a medium-sized myotis, closely resembling the little brown bat (*Myotis lucifugus*) but differing in coloration. Its fur is a dull grayfish chestnut rather than bronze, with the basal portion of the hairs of the back dull lead colored. This bat's underparts are pinkish to cinnamon, and its hind feet smaller and more delicate than in *M. lucifugus*. The calcar (heel of the foot) is strongly keeled. Little is known of this bat's diet beyond the fact that it consists of insects. Females and juveniles forage in the airspace near the foliage of riparian and floodplain trees. Males forage the densely wooded area at tree top height (LaVal et al. 1976, 1977).

Population

Global Abundance: 10,000 to >1,000,000 individuals. Total known population was estimated at about 550,000 in the early 1980s (USFWS 1983) and 353,000 in the mid-1990s (Federal Register, 9 April 1999, Vol 64, Number 68, pp 17406-17407).

Global Short-Term Trend: Declining (decline of 10 to 30 percent). Census data from 1995-1997 indicate an abundance decline of about 60 percent since population surveys began in the 1960s; the most severe declines have occurred in Kentucky and Missouri, where the decline totals 430,000 individuals over the past few decades (Federal Register, 9 April 1999, Vol 64, Number 68, pp 17406-17407).

---

[1] NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 21, 2006). US FWS ES. Species Account: Indiana Bat. http://www.fws.gov/endangered/i/a/saa08.html (Accessed June 16, 2006).

Distribution

The Indiana bat occurs in the Midwest and eastern United States from the western edge of the Ozark region in Oklahoma, to southern Wisconsin, east to Vermont, and as far south as northern Florida (Figure 6-1). In summer it is apparently absent south of Tennessee; in winter it is apparently absent from Michigan, Ohio, and northern Indiana where suitable caves and mines are unknown. About 350,000 individuals of this species were estimated in 1997, more than 200,000 fewer than the 1980 estimate, although definitive numbers are not possible, and populations have apparently been decreasing for many years. This number is roughly one-third of the number likely present as recently as the 1930s.

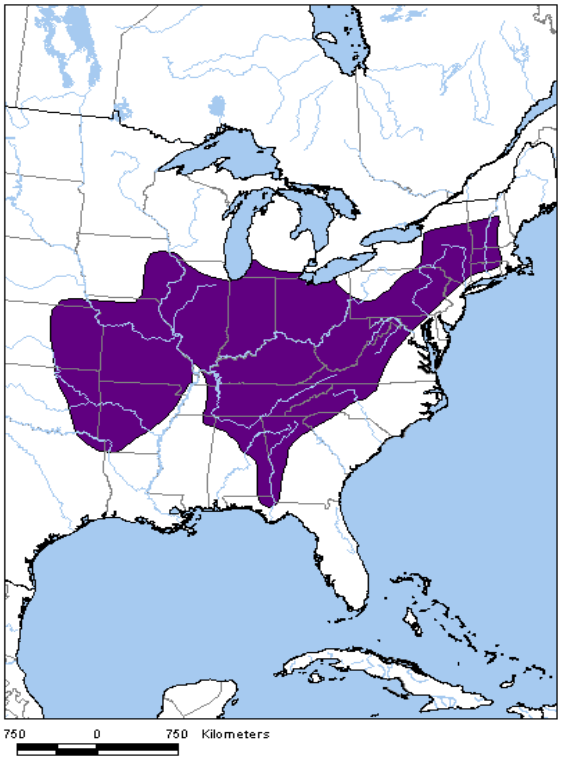

Figure 6-1. Distribution map for the Indiana bat.
The Indiana bat is a permanent resident in the shaded areas (NatureServe 2005).

Habitat

The Indiana bat uses limestone caves for winter hibernation. The preferred caves have a temperature averaging 37 degrees to 43 degrees F in midwinter, and a relative humidity averaging 87 percent. Summer records are rather scarce. A few individuals have been found under bridges and in old buildings, and several maternity colonies have been found under loose

bark and in the hollows of trees. Summer foraging by females and juveniles is limited to riparian and floodplain areas. Creeks are apparently not used if riparian trees have been removed, which is why the presence of snags is an important aspect of many Indiana bat habitat models. Males forage over floodplain ridges and hillside forests and usually roost in caves. Foraging areas average 11.2 acres per animal in midsummer.

Critical Habitat: The following caves have been designated as Critical Habitat within the Southeast Region:

Tennessee:	White Oak Blowhole Cave, Blount County
Kentucky:	Bat Cave, Carter County
	Coach Cave, Edmonson County

Threats and Reasons for Current Status

The decline in Indiana bat populations is attributed to commercialization of roosting caves, wanton destruction by vandals, disturbances caused by increased numbers of spelunkers and bat banding programs, use of bats as laboratory experimental animals, and possibly insecticide poisoning. Some winter hibernacula have been rendered unsuitable as a result of blocking or impeding air flow into the caves and thereby changing the cave's climate. The Indiana bat is nearly extinct over most of its former range in the northeastern states, and since 1950, the major winter colonies in caves of West Virginia, Indiana, and Illinois have disappeared. A high degree of aggregation during winter makes the species vulnerable. During this period approximately 87 percent of the entire population hibernates in only 7 caves.

Other Information

Reproduction and Development: This bat has a definite breeding period that usually occurs during the first 10 days of October. Mating takes place at night on the ceilings of large rooms near cave entrances. Limited mating may also occur in the spring before the hibernating colonies disperse.

Hibernating colonies disperse in late March and most of the bats migrate to more northern habitat for the summer. However, some males remain in the hibernating area during this period and form active bands that wander from cave to cave. During the fall, when these bats swarm and mate at their hibernacula, males roost in trees nearby during the day and fly to the cave during the night. Limited observations indicate that birth and devel-

opment occur in very small, widely scattered colonies consisting of 25 or so females and their young, though several instances of grouped colonies are known, and apparently hollow trees may serve as a summer roost for many colonies at one time. Birth usually takes place during June with each female bearing a single offspring. About 25 to 37 days are required for development to the flying stage and the beginning of independent feeding.

Migration to the wintering caves usually begins in August. Fat reserves depleted during migration are replenished largely during the month of September. Feeding continues at a diminishing rate until by late November when the population has entered a definite state of hibernation.

The hibernating bats characteristically form large, tight, compact clusters. Each individual hangs by its feet from the ceiling. Every 8 to 10 days hibernating individuals awaken to spend an hour or more flying about or to join a small cluster of active bats elsewhere in the cave before returning to hibernation. Hibernating individuals characteristically form large, compact clusters of as many as 5,000 individuals (averaging 500 to 1,000 bats per cluster; Hall 1962). These individuals may be difficult to discern in these clusters that average 300 individuals per square foot (LaVal and LaVal 1980). Clusters form in the same area in a cave each year, with more than one cluster possible in a particular cave (Hall 1962, Engel et al. 1976). Clustering may perform certain functions, such as protecting the central individuals from temperature changes (Twente 1955), reducing the sensitivity of most bats to external disturbance (Hall 1962), or rapid arousal and escape from predators (Humphrey 1978).

Food Sources: Flying insects are the typical prey items; diet reflects prey present in available foraging habitat. The bat forages along river and lake shorelines, in the crowns of trees in floodplains (Humphrey et al. 1977), and in upland forest (Brack and LaVal 1985). In Illinois, they generally foraged within about a mile of roost tree (Garner and Gardner 1992). In Indiana, reproductively active females showed a preference for foraging in floodplain forests with closed canopies and impounded water (farm ponds; Garner and Gardner 1992). The foraging habitat for an Indiana colony included an airspace 2 to 30 m above a stream and a linear distance of 0.8 km; foraging density was 17 to 29 bats/ha; feeding rate on aerial insects was 8 to 17 capture attempts/minute (Humphrey et al. 1977).

Army Installations Concerned

The following Army installations reported in the 2000 survey that the Indiana Bat was found on their property: Picatinny Arsenal, NJ; Iowa AAP, Middletown, IA; Newport Chemical Plant, Newport, IN; Camp Atterbury, Columbus, IN; Fort Campbell, KY; Fort Knox, KY; and Fort Leonard Wood, MO.

The following Army installations reported in the 2000 survey that the Indiana bat was known to be found on property contiguous to the Army lands: Rock Island Arsenal, Rock Island, IL; Macon Training Site, Macon, MO; and Fort Drum, Watertown, NY.

The general paucity of summer foraging locational information means that, to some degree, any riparian habitat over this broad area may support the Indiana bat to some degree. In general, the presence of older, larger, dead or dying, deciduous trees characterizes habitats the bats find attractive for the summer maternal colonies, which are very susceptible to disturbance.

Management and Protection

Includes Summary of the March 1999 Indiana Bat Recovery Plan.

The original Indiana bat recovery plan was approved in 1976, and revised plans were approved in October, 1983 and, most recently, in March, 1999. Some of the major recovery goals include: (1) preserving critical winter habitat by securing primary caves and mines and restricting entry; (2) initiating an information and education program; and, (3) monitoring population levels and habitat (to include an evaluation of pesticide effects).

To date, the primary conservation efforts have been to control/limit access by people by installing properly designed gates across cave entrances. Some gating has already been accomplished on federal and state lands. Gating of all seven of the major wintering hibernacula would provide protection for about 87 percent of the population, although improperly designed gates apparently have caused changes in air flow that are sufficient to degrade overwintering conditions, leading to population decreases. The acceptable temperature range during winter hibernation may, in some cases, be as small as ± 1 °C (±2°F).

In hibernation, limestone caves with pools are preferred. Hall (1962) noted that preferred caves are of medium size with large, shallow passageways. Roosts usually are in the coldest part of the cave. Preferred sites have a mean midwinter air temperature of 4 to 8 °C (the bat tolerates a much broader range; Hall 1962, Henshaw and Folk 1966), well below that of caves that are not chosen (Clawson et al. 1980). The roost site within a cave may shift such that bats remain in the coldest area (Clawson et al. 1980). The bats may move from a location deeper in the cave to a site nearer the entrance as the cold season progresses; they move away from areas that go below freezing. Hibernation in the coldest parts of the cave ensures a sufficiently low metabolic rate so that the fat reserves last through the 6-month hibernation period (Henshaw and Folk 1966, Humphrey 1978). Relative humidity in occupied caves ranges from 66 to 95 percnt and averages 87 prcent throughout the year (Barbour and Davis 1969, Clawson et al. 1980). Because of these requirements, *M. sodalis* is highly selective of hibernacula.

During the fall, when these bats swarm and mate at their hibernacula, males roost in trees nearby during the day and fly to the cave during the night. In Kentucky, Kiser and Elliott (1996) found males roosting primarily in dead trees on upper slopes and ridgetops within 2.4 km of their hibernaculum. During September in West Virginia, males roosted within 5.6 km in trees near ridgetops, and often switched roost trees from day to day (C. Stihler, West Virginia Division of Natural Resources, pers. observ. October 1996, cited in USFWS 1999). Fall roost trees tend to be in sunnier areas rather than being shaded (J. MacGregor, pers. observ. October 1996, cited in USFWS 1999).

In summer, habitat consists of wooded or semiwooded areas, mainly along streams. Solitary females or small maternity colonies bear their offspring in hollow trees or under loose bark of living or dead trees (Humphrey et al. 1977, Garner and Gardner 1992). Humphrey et al. (1977) determined that dead trees are preferred roost sites and that trees standing in sunny openings are attractive because the air spaces and crevices under the bark are warmer. In Illinois, Garner and Gardner (1992) found that typical roosts were beneath the exfoliating bark of dead trees; other roost sites were beneath the bark of living trees and in cavities of dead trees. Kurta et al. (1993) found a large maternity colony in a dead, hollow, barkless, unshaded sycamore tree in a pasture in Illinois. In Michigan, a reproductively active colony occupied eight different roost trees (all green ash), all

of which were exposed to direct sunlight throughout the day; bats roosted beneath loose bark of dead trees (Kurta et al. 1993). In western Virginia, a male used a mature, live, shagbark hickory tree as a diurnal roost; the bat foraged primarily among tree canopies of an 80-year-old oak-hickory forest (Hobson and Holland 1995). In Missouri, primary maternity roosts were in standing dead trees exposed to direct sunlight; there were 1 to 3 primary roosts per colony; alternate roosts were in living and dead trees that typically were within the shaded forest interior (Callahan et al. 1997). See Garner and Garner (1992) for detailed information on summer habitat in Illinois. Though maternity sites have been reported as occurring mainly in riparian and floodplain forests (Humphrey et al. 1977, Garner and Gardner 1992), recent studies indicate that upland habitats are used by maternity colonies much more extensively than previously reported. Garner and Gardner (1992) reported that 38 of 51 roost trees in Illinois occurred in uplands and 13 trees were in floodplains. Of the 47 trees in forested habitat, 27 were in areas having a closed (80 to 100 percent) canopy, and 15 were in areas having an intermediate (30 to 80 percent) canopy. Isolated, single roost trees were found in the following types of habitat: a heavily grazed ridgetop pasture with a few scattered dead trees, a partially wooded swine feedlot, a palustrine wetland with emergent vegetation, a forested island in the Mississippi river, and a clearcut around a segment of an intermittent stream where dead trees were retained for wildlife. Roosts were not found in forests with open canopies (10 to 30 percent) nor in old fields with less than or equal to 10 percent canopy cover. Though maternity sites have been reported as occurring mainly in riparian and floodplain forests (Humphrey et al. 1977, Garner and Gardner 1992), recent studies indicate that upland habitats are used by maternity colonies much more extensively than previously reported (Garner and Gardner 1992).

All habitat models for Indiana bat incorporate snags and hollow trees as major elements. USFWS biological opinions on hardwood forest management require that a ½-acre cluster of snags and older trees be left for each 20 acres to be harvested, unless similar resources are located immediately adjacent to the harvest area. The clear implication is that similar care must be taken in clearing for construction, including training area management and range development. The necessity for a Section 7 consultation for small construction site preparation may not be immediately obvious to most planners, or even to biologists who have not been sensitized to this issue.

Military Training Considerations: With respect to military interaction with the Indiana bat, there apparently are no major hibernacula on military-owned or -managed lands. Many installations, however, may have, or are known to have, limestone solution caves that could host smaller winter roosts. Forts Leonard Wood, Knox, and Campbell fit this definition. The great generalizations with which summer habitat is described means that in theory, almost any hardwood forest near a body of water has potential to be used as summer habitat. It is this potential that makes it difficult to firmly exclude the bat from concern across wide ranges of most of the eastern third of the United States. Further, the Indiana bat may be found associated with much larger numbers of other bat species for much of this time, and living in mixed colonies where they are usually the great minority of bats present. Thus, the presence of bats within the range does not reliably tell one that the endangered species is there, and many surveys may find only one or two Indiana bats among hundreds of other animals.

When examining the traditional three sources of military-unique stressors, (i.e., heavy weapons, in-field maneuvers, and use of obscurant smokes), all have some potential for disruption of Indiana (and gray) bat summer activities. From a population viability point of view, the risk is greatest for adverse effects, direct and indirect, on summer maternal colonies. At this time, studies are being undertaken by the Army to examine noise effects (ongoing at Fort Knox), and effects on insect prey species as use of fog oil obscurant smoke may affect food sources for the nursing females. It appears that relatively little direct risk from maneuver is likely, although the possibility of accidentally or unknowingly destroying a colony tree exists in many locations. Confirmation of the presence of these colonies is complex, and uncertain. At the present level of technology, field techniques appear to be limited to confirmation that some bats are present. Quantification of numbers and species appears to remain in the research realm, and is not yet a simple field procedure, although Army and other biologists are working on the means to do so.

References

References cited in this chapter and selected additional sources for more information.

52 Federal Register (FR) 7426, March 11, 1967.

Federal Register, 9 April 1999, Vol 64, Number 68, pp 17406-17407.

Baker, R. H. 1983. Michigan mammals. Michigan State University Press. 642 pp.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. The University Press of Kentucky. Lexington. 286 pp.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. The University of Kentucky Press, Lexington, Kentucky.

Brack, V., Jr., and K. Tyrell. 1990. A model of the habitat used by the Indiana bat (MYOTIS SODALIS) during the summer in Indiana: 1990 field studies. Indiana Dept. Natural Resources, Div. Fish Wildlife, Endangered Species Program, Project E-1-4, Study No. 8. 45 pp.

Brack, V., Jr., and R. K. LaVal. 1985. Food habits of the Indiana bat in Missouri. J. Mammology 66:308-315.

Brady, J., R. L. Clawson, R. K. LaVal, T. Kunz, M. D. Tuttle, and D. Wilson. 1983. Recovery plan for the Indiana bat. U. S. Fish Wildlife Service, Rockville, Maryland. 94 pp.

Brady, J., T. Kunz, M. D. Tuttle, and D. Wilson. 1982. Gray Bat Recovery Plan. U.S. Fish Wildlife Service 140 pp.

Caire, W., J. D. Tyler, B. P. Glass, and M. A. Mares. 1989. Mammals of Oklahoma. University of Oklahoma Press, Norman. Oklahoma. 567 pp.

Callahan, E. V., R. D. Drobney, ad R. L. Clawson. 1997. Selection of summer roosting sites by Indiana bats (MYOTIS SODALIS) in Missouri. Journal of Mammology 78:818-825.

Choate, J. R., J. K. Jones, Jr., and C. Jones. 1994. Handbook of mammals of the south-central states. Louisiana State University Press, Baton Rouge. 304 pp.

Clawson, R. L., R. K. LaVal, M. L. LaVal, and W. Claire. 1980. Clustering behavior of hibernating MYOTIS SODALIS in Missouri, USA. Journal of Mammology 61:245-53.

Cope, J. B., A. R. Richter, and R. A. Mills. 1974. A summer concentration of the Indiana bat, MYOTIS SODALIS, in Wayne Co., Indiana. Proc. Indiana Acad. Sci. 83:482-4.

Cope, J. B., and S. R. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, MYOTIS SODALIS. Journal of Mammology 58:93-5.

Dalton, V. M. 1987. Distribution, abundance, and status of bats hibernating in caves in Virginia. Virginia J. Science 38:369-379.

Engel, J. M. 1976. THE INDIANA BAT, MYOTIS SODALIS: A BIBLIOGRAPHY. U.S. FISH & WILDLIFE SERV., SPECIAL SCIENTIFIC REPORT-WILDLIFE NO. 196. 11 PP.

Engel, J. M. et al. 1975. RECOVERY PLAN FOR THE INDIANA BAT. U.S. FISH AND WILDLIFE SERVICE. 36 PP.

Engel, J. M., F. R. Cowresal, R. L. Marin, J. R. Messerli, T. H. Hooper, R. E. Mumford, and L. E. Terry. 1976. Indiana bat recovery plan. U.S. Fish and Wildlife Service. 106 pp.

Evers, D. C. 1992. A guide to Michigan's endangered wildlife. Univ. Michigan Press, Ann Arbor. viii + 103 pp.

Figg, D. E. 1991. Missouri Department of Conservation Annual Nongame and Endangered Species Report July 1990 - June 1991. ii + 35 pp.

Figg, D. E. 1993. Missouri Department of Conservation wildlife diversity report, July 1992-June 1993. 75 pp.

Figg, D. E., and C. M. Bessken. 1995[?]. Missouri Department of Conservation wildlife diversity report: July 1994 - June 1995. v + 104 pp. [perhaps date is 1996]

Garner, J. D. 1991. Determination of summer distribution and habitat utilization of the Indiana bat (MYOTIS SODALIS) in Illinois. Final report submitted to the Illinois Natural History Survey. 23 pp.

Garner, J. D., and J. E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (MYOTIS SODALIS) in Illinois. Illinois Department of Conservation. Final Report, Project E-3. Springfield, IL, 23 pp.

Gene Gardner. Biologist. Illinois Natural History Survey. 607 East Peabody Drive, Champaign, IL. (217) 244-6283.

Guthrie, M. J. 1933. The reproductive cycles of some cave bats. Journal of Mammology 14:199-216.

Hall, E. R. 1981. The Mammals of North America. Second edition. 2 Volumes. John Wiley and Sons, New York, New York.

Hall, J. S. 1962. A life history and taxonomic study of the Indiana bat, MYOTIS SODALIS. Reading Publication Museum Art Gallery, Science Publication 12. 68 pp.

Hamilton, W. J., Jr., and J. O. Whitaker, Jr. 1979. Mammals of the eastern United States. Cornell Univ. Press, Ithaca, New York. 346 pp.

Handley, C. O., Jr. 1991. Mammals. Pages 539-616 in K. Terwilliger, coordinator. Virginia's endangered species: proceedings of a symposium. McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Harvey, M. J. 1987. Recent population declines and recovery efforts for the endangered Indiana bat MYOTIS SODALIS, in Arkansas and Tennessee. (Abstract). Bat Research News 28(3-4):35.

Hassell, M. D. 1963. A study of homing in the Indiana bat, MYOTIS SODALIS. Trans. Kentucky Acad. Sci. 24:1-4.

Hassell, M. D. 1967. Intra-cave activity of four species of bats, hibernating in Kentucky. University of Kentucky. Ph. D. dissertation.

Hassell, M. D., and M. J. Harvey. 1965. Differential homing in MYOTIS SODALIS. Am. Mid. Nat. 74:501-3

Henshaw, R. E., and G. E. Folk. 1966. Relation of thermo-regulation to seasonally changing microclimate in 2 species of bats, MYOTIS LUCIFUGUS and M. SODALIS. Physiol. Zool.39:223-36.

Herkert, J. R., editor. 1992. Endangered and threatened species of Illinois: status and distribution. Vol. 2: Animals. Illinois Endangered Species Protection Board. iv + 142 pp.

Hobson, C. S., and J. N. Holland. 1995. Post-hibernation movement and foraging habitat of a male Indiana bat, MYOTIS SODALIS (Chiroptera: Vespertilionidae), in western Virginia. Brimleyana 23:95-101.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, MYOTIS SODALIS. Florida Scientist 41(2):65-76.

Humphrey, S. R., and J. B. Cope. 1977. Survival rates of the endangered Indiana bat, MYOTIS SODALIS. Journal of Mammology 58:32-6. Humphrey, Stephen R., A. R. Ritcher, and J. B. Coper. 1977. Summer Habitat and Ecology of the Endangered Indiana Bat, Myotis sodalis. J. Mammal. 58:334-346.

Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, MYOTIS SODALIS. J. Mammology 58:334-346.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, MYOTIS SODALIS. Florida Scientist 41(2):65-76.

Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, MYOTIS SODALIS. J. Mammalogy 58:334-346.

Johnson, S. A., V. Brack, Jr., and R. E. Rolley. 1998. Overwinter weight loss of Indiana bats (Myotis sodalis) from hibernacula subject to human visitation. American Midland Naturalist 139:255-261.

Jones, J. K., Jr., R. S. Hoffman, D. W. Rice, C. Jones, R. J. Baker, and M. D. Engstrom. 1992. Revised checklist of North American mammals north of Mexico, 1991. Occasional Papers, The Museum, Texas Tech University, 146:1-23.

Kiser, J. D. and C. L. Elliott. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (MYOTIS SODALIS) during autumn in Johnson County, Kentucky. Final report, Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky. 65pp.

Kurta, A. 1995. Mammals of the Great Lakes region. Univ. Michigan Press, Ann Arbor. xii + 376 pp.

Kurta, A., and J. A. Teramino. 1994. A novel hibernaculum and noteworthy records of the Indiana bat and eastern pipistrelle (Chiroptera: Vespertilionidae). American Midland Naturalist 132:410-413.

Kurta, A., et al. 1993. A maternity roost of the endangered Indiana bat (Myotis sodalis) in an unshaded, hollow, sycamore tree (Platanus occidentalis). American Midland Naturalist 130:405-407.

Kurta, A., et al. 1993. Summer roosts of the endangered Indiana bat (Myotis sodalis) on the northern edge of its range. American Midland Naturalist 129:132-138.

LaVal, R. K., R. L. Clawson, W. Caire, L. R. Wingate, and M. L. LaVal. 1976. An Evaluation of the Status of Myotine Bats in the Proposed Meramec Park and Union Lake Project Areas, Missouri. School of Forestry, Fisheries and Wildlife, University of Missouri, Columbia. 136 pp.

LaVal, R. K., R. L. Clawson, M.L. LaVal, and W. Caire. 1977. Foraging Behavior and Nocturnal Activity Patterns of Missouri Bats, With Emphasis on the Endangered Species Myotis grisescens and Myotis sodalis. J. Mammal. 58:592-599.

LaVal, R. K., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave dwelling species. Terrestrial Series 8, Missouri Department of Conservation.

Layne, J. N., editor. 1978. Rare and endangered biota of Florida. Vol. 1. Mammals. State of Florida Game and Freshwater Fish Commission. xx + 52 pp.

Lowe, D. W. 1990. Indiana Bat, MYOTIS SODALIS. Pages 506-8 in J. R. Matthews, and C. J. Moseley (editors). The official World Wildlife Fund guide to endangered species of North America.

Matthews, J. R., and C. J. Moseley (editors). 1990. The Official World Wildlife Fund Guide to Endangered Species of North America. Volume 1. Plants, Mammals. xxiii + pp 1-560 + 33 pp. appendix + 6 pp. glossary + 16 pp. index. Volume 2. Birds, Reptiles, Amphibians, Fishes, Mussels, Crustaceans, Snails, Insects, and Arachnids. xiii + pp. 561-1180. Beacham Publications, Inc., Washington, D.C.

Mohr, C. E. 1972. The status of threatened species of cave-dwelling bats. Bull. Nat. Speleol. Soc. 34(2):33-47.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 21, 2006).

Nowak, R. M. 1991. Walker's mammals of the world. Fifth edition. Vols. I and II. Johns Hopkins Univ. Press, Baltimore. 1629 pp.

Ransome, R. 1990. The natural history of hibernating bats. Christopher Helm, London. xxi + 235 pp.

Refsnider, R. Biologist. U.S. Fish and Wildlife Service. Enhancement (Attention SE). One Federal Drive. Fort Snelling, MN 55111. (612)725-3276.

Richter, A. R., et al. 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (MYOTIS SODALIS). Conservation Biology 7:407-

Saugey, D. A., et al. 1990. Hibernating Indiana bats (MYOTIS SODALIS) from the Ouachita Mountains of southwestern Oklahoma. Southwestern Naturalist 35:341-342.

Schwartz, C. W., and E. R. Schwartz. 1981. The wild mammals of Missouri. University of Missouri Press, Columbia. 356 pp.

Sealander, J. A. 1979. A guide to Arkansas mammals. River Road Press, Conway. 313 pp.

Thom, R. H. 1981. Endangered and threatened mammals. Pages 59-69 in M. Bowles, editor. Endangered and threatened vertebrate animals and vascular plants of Illinois. Natural Land Institute, Rockford, Illinois.

Thompson, C. E. 1982. MYOTIS SODALIS. Mammalian Species No. 163:1-5.

Tuttle, M. D. 1977. Gating as a means of protecting cave dwelling bats. Pages 77-82 in T. Aley and D. Rhodes, editors. National cave management symposium proceedings.

Tuttle, M. D., and D. E. Stevenson. 1978. Variation in the cave environment and its biological implications. Pages 108-21 in R. Zuber (editor). National Cave Management Symposium Proceedings.

Twente, J. W. 1955. Some aspects of habitat selection and other behavior of cavern-dwelling bats. Ecology 36:706-32.

U.S. Department of Agriculture. 1975. Endangered, Threatened and Unique Mammals of the Southern National Forests. U.S. Forest Service, Atlanta, Georgia. 121 pp.

U.S. Department of Interior. 1978. Species Accounts for Sensitive Wildlife Information System (SWIS). Fish and Wildlife Service, National Wildlife Laboratory, Gainesville, Florida.

U.S. Fish and Wildlife Service (USFWS). 1990. Endangered and threatened species recovery program: report to Congress. 406 pp.

USFWS. 1999. Agency draft Indiana Bat (MYOTIS SODALIS) revised recovery plan. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 53pp.

USFWS in Cooperation with the Indiana Bat Recovery Team. 1983. Recovery Plan for the Indiana Bat. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 82 pp.

USFWS-ES. Species Account: Indiana Bat. http://www.fws.gov/endangered/i/a/saa08.html (Accessed June 16, 2006).

Wilson, D. E., and D. M. Reeder (editors). 1993. Mammal Species of the World: a Taxonomic and Geographic Reference. Second Edition. Smithsonian Institution Press, Washington, DC. xviii + 1206 pp. Available online at: http://www.nmnh.sci.edu/msw/.

7 Species Profile for the Lesser Long-Nosed (Sanborn's) Bat

Lesser Long-nosed (Sanborn's) Bat[1]

Leptonycteris curasoae yerbabuenae

Status

U.S. Endangered Species Act: LE: Listed endangered (53 FR 38456 September 30, 1988) U.S. Fish and Wildlife Service Lead Region: R2 – Southwest.

USFWS (1988, 1997) reported a long-term decline. Cockrum and Petryszyn (1991) strongly disputed the reported decline of this species and, in reviewing pertinent data, concluded that little evidence exists to document a long-term decline in Arizona, New Mexico, and Sonora; these authors stated "the various recent reports of disappearance appear to be, at least in part, the result of not looking in the right places at the right times" and further reported that "current populations...are little, if any, decreased from those of a quarter century ago. It even has been suggested that populations have increased in the past century because of more suitable roosts being available as a result of mining activity in the area." USFWS (1994) categorized the status as "unknown." A notice announcing a 5-year review of this species was published in 2005 (70 FR 5460, February 2, 2005).

Description

The lesser long-nosed bat is a medium size, leaf-nosed bat. It has a long muzzle, a long tongue, and is capable of hover flight. These features are adaptations that allow the bat to feed on nectar from the flowers of columnar cacti such as the saguaro (*Cereus giganteus*) and organ pipe cactus (*Stenocereus thurberi*), and from paniculate agaves such as Palmer's agave (*Agave palmeri*) and Parry's agave (*A. parryi*; Hoffmeister 1986).

[1] NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 16, 2006). This reference information came from the BISON-M (Biota Information System of NM) database. The information was derived directly from data in this species account: Biota Information System of New Mexico (BISON). Species account number 050065. Lesser Long-nosed Bat. http://www.fw.vt.edu/fishex/nmex_main/species/050065.htm Website last updated: January 2000. (Accessed June 21, 2006).

Palmer's agave exhibits many characteristics indicating they are pollinated by bats, such as nocturnal pollen dehiscence and nectar production, light colored and erect flowers, strong floral odor, and high levels of pollen protein with relatively low levels of nectar sugar concentrations (Slauson 1996). Parry's agave demonstrates many (although not all) of these same morphological features (Gentry 1982). Slauson (1999) has demonstrated that there was a mutualistic relationship between Palmer's agave and the lesser long-nosed bat, though this relationship was asymmetric. The bat is quite dependent on the agave for food during a certain period, but the agave has other pollinator options.

The lesser long-nosed bat is one of four members of the tropical bat family Phyllostomidae that are found in the United States. It was formally separated from the Mexican long-nosed bat (*L. nivalis*) as a distinct species (*L. sanborni*) by Hoffmeister (1957). *L. nivalis* is a monotypic species that occurs in Mexico and southwestern New Mexico and Texas. Arita and Humphrey (1988) reviewed the taxonomic status of bats of the genus Leptonycteris and concluded that *L. sanborni* is conspecific with *L. curasoae* of northern Venezuela and the Dutch Antilles. They recognized two subspecies of *L. curasoae*; a northern subspecies (*L. c. yerbabuenae* = *L. sanborni*) found in Mexico and southern Arizona and New Mexico and a southern subspecies (*L. c. curasoae*) found in northern South America. Wilkinson and Fleming (1995) have confirmed the genetic distinctiveness of the two subspecies of *L. curasoae* and the specific distinction between *L. curasoae* and *L. nivalis* using molecular data.

The lesser long-nosed bat is a medium-sized bat with a forearm measuring 51 to 56 mm (2.0 to 2.2 in.) and weighing 20 to 25 grams (0.7 to 0.9 oz) as an adult. Adult fur is grayish to reddish-brown; juveniles have gray fur. Its elongated rostrum bears a small, triangular noseleaf, its ears are relatively small and simple in structure, and it has a minute tail. It is generally smaller in external and cranial measurements than *L. nivalis*. *L. curasoae* can be distinguished from the Mexican long-tongued bat (*Choeronycteris mexicana*), with which it co-occurs in Arizona, by the larger size, less elongated snout, and tiny tail.

Distribution

Lesser long-nosed bats are found in Arizona from the Picacho Mountains south and west to the Agua Dulces, and south and east to the Chiricahuas, and into Mexico. They are also found in southwestern New Mexico, Baja

California, and well into Central America. Those that summer in the United States winter in Mexico, but they do not hibernate (Monday 1993). In the United States, they are most commonly found between 900 and 1500 m elevation, and in almost any rough terrain providing either food (primarily the Palmer agave) or shelter (primarily caves and abandoned mines). Lesser long-nosed bats are known in the United States only during warmer months (Hayward and Cockrum 1971, Findley et al. 1975, Schmidly 1977, Wilson 1985, Hensley and Wilkins 1988; New Mexico Department of Game and Fish 1996). Only the very most northern locations are in the United States (Figure 7-1).

Figure 7-1. The geographic distribution of *Leptonycteris curasoae yerbabuenae*, based on Arita (1991).

Stars indicate locations of major maternity roosts. Solid circles indicate non-maternity roosts. Roosts are: 1) Bluebird and Copper Mountain Mines, 2) Old Mammon Mine, 3) Pinacate Cave, 4) Patagonia Bat Cave, 5) Hilltop Mines, 6) Tajitos Mine, 7) Cueva de1 Tigre, 8) Sierra Kino-Isla Tiburon Caves, 9) Santo Domingo Mine, 10) Isla San Andres Cave, 11) Cueva "La Mina," 12) Gruta Juxtlahuaca, 13) Cueva "Rancho Tempisque," 14) Cueva "La Capilla" - San Antonio Mine, 15) Cueva Mulege. (Map provided by U.S. Fish and Wildlife Service. 1997. Lesser long-nosed bat recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 45 pp.)

The lesser long-nosed bat is migratory and found throughout its historic range, from southern Arizona and extreme southwestern New Mexico, through western Mexico, and south to El Salvador. In southern Arizona lesser long-nosed bat roosts have been found from the Picacho Mountains (Pinal County) southwest to the Agua Dulce Mountains (Pima County), southeast to the Chiricahua Mountains (Cochise County) and south to the international boundary. Individuals have also been observed from the vicinity of the Pinaleno Mountains (Graham County) and as far north as the McDowell Mountains (Maricopa County; Arizona Game and Fish Depart-

ment 1996). This bat is also known from far southwestern New Mexico in the Animas and Peloncillo Mountains (Hidalgo County). It is a seasonal resident in Arizona, usually arriving in early April and leaving in mid-September to early October (Figure 7-2). It resides in New Mexico only from mid-July to early September (Hoyt et al. 1994).

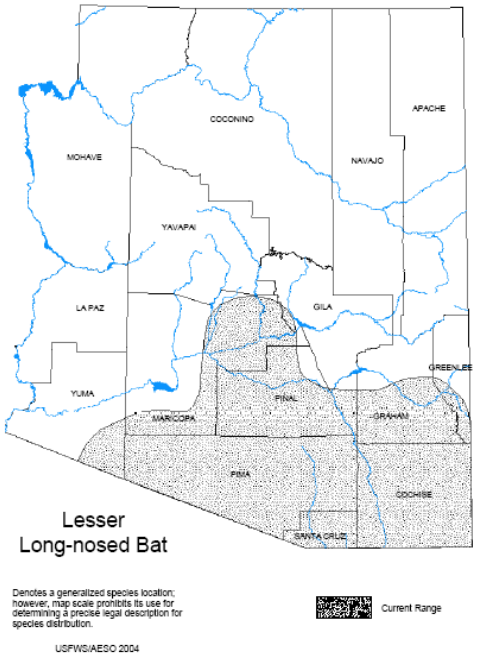

Figure 7-2. A generalized species location for the lesser long-nosed bat in Arizona. Gray area is the current range of the bat.

The roosts in Arizona are occupied from late April to October (Cockrum and Petryszyn 1991, Sidner 1997). In spring, adult females, most of which are pregnant, arrive in Arizona and gather into maternity colonies in southwestern Arizona. These roosts are typically at low elevations near concentrations of flowering columnar cacti. Litter size is one. After the young are weaned, these colonies disband in July and August; some females and young move to higher elevations, ranging up to more than 1,818 m (6,000 ft), primarily in the southeastern parts of Arizona near concentrations of blooming paniculate agaves. Actual dates of these seasonal movements by lesser long-nosed bats are rather variable from one year to the next (Cockrum and Petryszyn 1991, Fleming et al. 1993). Adult males typically occupy separate roosts forming bachelor colonies. Males are known mostly from the Chiricahua Mountains but also occur with adult females and young of the year at maternity sites (USFWS 1997). Throughout the night between foraging bouts, both sexes will rest in temporary night roosts (Hoffmeister 1986).

The lesser long-nosed bat consumes nectar and pollen of paniculate agave flowers and the nectar, pollen, and fruit produced by a variety of columnar cacti. In Arizona, four species of agave and two cacti are the main food plants (Hayward and Cockrum 1971, Wilson 1985). The agaves include Palmer's agave, Parry's agave, desert agave (*A. deserti*), and amole (*A. schottii*). Amole is considered to be an incidental food source. The cacti include saguaro and organpipe cactus. Nectar of these cacti and agaves are high-energy foods. Concentrations of food resources appear to be distributed in patches on the landscape and the nectar of each plant species utilized is only seasonally available. Cacti flowers and fruit are available during the spring and early summer; blooming agaves are available through the summer, primarily from July through early October, though Parry's agave blooms earlier. Columnar cacti occur in lower elevation areas of the Sonoran Desert region, and paniculate agaves are found primarily in higher elevation desert scrub areas, desert grasslands and shrublands, and into the mountains. Parry's agave is usually found at higher elevations than Palmer's agave (Gentry 1982). The bats are generally considered to time their movement and feeding to the progression of flowering associated with these cacti and agaves. Many species of columnar cacti and agaves appear to provide a "nectar corridor" for lesser long-nosed bats as they migrate in spring from Central America and Mexico to as far north as southern Arizona, through fall when they return south (Gentry 1982, Flemming et al. 1993, Slauson et al. 1998).

Lesser long-nosed bats appear to be opportunistic foragers and efficient fliers, capable of flight speeds up to 23 kilometers per hour (14 mph) (Sahley et al. 1993), and often foraging in flocks. Seasonally available food resources may account for the seasonal movement patterns of the bat. The lesser long-nosed bat is known to fly long distances from roost sites to foraging sites. One-way night flights from maternity colonies to flowering columnar cacti have been documented in Arizona at 24 km (15 mi), and in Mexico at 40 km (25 mi) and 61 km (38 mi; Dalton et al. 1994; V. Dalton, Tucson, pers. comm., 1997; Y. Petryszyn, University of Arizona, pers. comm., 1997). A substantial portion of the lesser long-nosed bats at the Pinacate Cave in Sonora (a maternity colony) fly 40 to 50 km (25 to 31 mi) each night to foraging areas in Organ Pipe Cactus National Monument (USFWS 1997). Horner et al. (1990) found that lesser long-nosed bats commuted 48 to 58 km (30 to 36 mi) round trip between an island maternity roost and the mainland in Sonora; the authors suggested these bats regularly flew at least 80 to 100 km (50 to 62.5 mi) each night. Lesser

long-nosed bats have been observed feeding at hummingbird feeders many miles from the closest potential roost site (Petryszyn, pers. comm. 1997).

The lesser long-nosed bat was listed (originally, as *Leptonycteris sanborni*; Sanborn's long-nosed bat) as endangered in 1988 (USFWS 1988). No critical habitat has been designated for this species. The recovery plan was completed in 1997 (USFWS 1997). Loss of roost and foraging habitat, as well as direct taking of individual bats during animal control programs, particularly in Mexico, have contributed to the current endangered status of the species. There has been a significant degree of debate and controversy regarding the actual population size and appropriate listing status of the species. The recovery plan states that the species will be considered for delisting when three major maternity roosts and two post-maternity roosts in the United States, and three maternity roosts in Mexico have remained stable or increased in size for at least 5 years, following the approval of the recovery plan.

Suitable day roosts and suitable concentrations of food plants are the two resources that are crucial for the lesser long-nosed bat (USFWS 1997). Caves and mines are used as day roosts. The factors that make roost sites useable have not yet been identified. Whatever the factors are that determine selection of roost locations, the species seems sensitive to human disturbance. Instances are known where a single brief visit to an occupied roost is sufficient to cause a high proportion of lesser long-nosed bats to temporarily abandon their day roost and move to another. Perhaps most disturbed bats return to their preferred roost in a few days. However, this sensitivity suggests that the presence of alternate roost sites may be critical when disturbance occurs. Interspecific interactions with other bat species may also influence lesser long-nosed bat roost requirements.

Considerable evidence exists suggesting a dependence of Leptonycteris on certain agaves and cacti, although some Palmer's agave has been shown not to be dependent on Leptonycteris for pollination (Slauson 1996, 1999; Slauson et al. 1998). Activities that adversely affect the density and productivity of columnar cacti and paniculate agaves may adversely affect populations of lesser long-nosed bats (Abouhalder 1992, USFWS 1997). Excess harvest of agaves in Mexico, collection of cacti in the United States, and conversion of habitat due to urban expansion, agricultural uses, livestock grazing, and other development may contribute to the decline of

long-nosed bat populations (USFWS 1988). Livestock grazing in areas with agaves may affect the long-nosed bat, particularly under high intensity use. Intense grazing can result in trampling of young agaves and cacti, soil compaction, erosion, alteration of the plant community species composition and abundance, and changes in the natural fire regime. Activities that directly or indirectly promote invasions or increased density of nonnative grasses, particularly Lehmann lovegrass (*Eragrostis lehmanniana*), species of Bromus, and Mediterranean grass (*Schismus barbatus*), may result in increased fire frequency and intensity (Minnich 1994) which in turn may have related impacts to paniculate agave and columnar cacti populations. Grasses are probably the strongest competitors of agave seedlings (L. Slauson, Desert Botanical Gardens, Phoenix, pers. comm., 1997). Agaves are monocarpic, flowering only once and then dying. Livestock and wild herbivores feed on young agave stalks, which precludes the plant from flowering. Saguaros are also affected by livestock activity. Saguaros are dependent on nurse plants to provide cover during their sensitive seedling stage. Livestock grazing may affect the density and distribution of nurse plants, increasing the mortality of saguaro seedlings. Young cacti may also be trampled and compaction and reduced infiltration may adversely alter germination sites.

Food requirements of the lesser long-nosed bat are very specific. Adequate numbers of flowers or fruits are required within foraging range of day roosts and along migration routes to support large numbers of this bat. Locations of good feeding sites play an important role in determining availability of potential roosting sites, and roost/food requirements must be considered jointly when discussing the habitat requirements of this bat. A suitable day roost is probably the most important habitat requirement, but potentially suitable roosts must be within reasonable foraging distances of sufficient amounts of required foods before this bat will use them. It seems evident that the lesser long-nosed bat forages over wide areas and that large roosts require extensive stands of cacti or agaves for food. Therefore, destruction of food plants many kilometers from a roost could have a negative impact on this bat (USFWS 1997).

The lesser long-nosed bat recovery plan (USFWS 1997) identifies the need to protect foraging areas and food plants. Columnar cacti and agaves provide critical food resources for this bat. Populations of these plants need continued protection to sustain nectar-feeding bat populations. A critical need in this area is information about the size of the foraging areas around

roosts so that adequate areas can be protected. This information will show the minimum area needed to support a roost of nectar- and fruit-eating bats, provided the roost locations are known.

Known major roost sites for the lesser long-nosed bat include 16 large roosts in Arizona and Mexico (USFWS 1997). According to surveys conducted in 1992 and 1993, the number of bats estimated to occupy these sites was greater than 200,000. Twelve major maternity roost sites are known from Arizona and Mexico. According to the same surveys, the maternity roosts are occupied by a total of more than 150,000 lesser long-nosed bats. The numbers above indicate that, although many of these bats are known to exist, the relative number of known large roosts is small. Disturbance of these roosts and the food plants associated with them could lead to the loss of the roosts. Limited numbers of maternity roosts may be the critical factor in the survival of this species.

Threats and Reasons for Decline

Food supply. The summer (and maternal colony) food source is overwhelmingly the flowers of the Palmer agave. Other species of agave and several cacti, including the giant saguaro, provide pollen, nectar, soft pulp, and, occasionally, fruits, which make up the diet of the bat. Grazing by livestock has direct and indirect effects on the abundance of flowering agaves. On Fort Huachuca, where grazing by domestic livestock has not been recently allowed, grazing by native deer, pronghorn, and other ungulates may be having a similar negative effect by direct consumption of the immature flowering culms before the flowers open, thus depriving the bat of both nectar and pollen. If a nearby maternal colony is dependent on this food supply, significant mortality of pups may be seen. Range fires caused by a combination of excess growth of invasive grasses, such as Bromus and Lehman lovegrass, with use of incendiary munitions, may affect agave success and be a cause of colony abandonment.

Colony Disturbance. The summer colonies, especially maternal colonies, are vital to population maintenance. Intrusion into caves and mines may cause abandonment of the sites, as may other intrusive or disturbing activities such as its use as an impact area, construction site, fighting position, or other similar use. The effects of weapons usage and aircraft operations in the vicinity of colonies have not been quantified.

Agave Recruitment. As noted above, the species is largely dependent on the flowers of *Agave palmeri* for its food supply, though this is supplemented by many smaller sources. Grazing, vehicle use, and fire all have been known to reduce the establishment of seedlings of the agave. One source notes that the success of coyote control in many areas in the past has probably caused an increase in the efficiency with which the woodrat consumed agave seeds, also leading to fewer seedlings and, therefore, fewer agaves being established. While the plant is a perennial, its habit of dying to the ground after flowering and fruiting means that continuous re-establishment of new plants is vital to long-term survival. Heavy training use of military vehicles should have the effect of damage to flowering potential of existing mature plants as well as permanent loss of seedlings. Unnaturally intensive wildfire, promoted by growth of invasive weedy species, may also kill younger agaves.

Other Information

Comments on Culture: Because of public health concerns associated with diseases such as rabies, bats, known hosts of the causative virus for rabies (and known vectors for other zoonotic diseases), have become subjects of many studies aimed at getting a handle on the status of current bat populations. Bat guano is an important source of fertilizer and houses unique organisms that are useful in the production of waste detoxifying agents, gasohol, and antibiotics (Snow 1973).

Observations on Habitat Requirements: We examined 20 long-nosed bats (14 males and 6 females) from southwestern Hidalgo County, 19 from the Peloncillo Mountains and 1 from Double Adobe Canyon at the north end of the Animas Range. The last locality, at 5,600 feet, appears to be at the upper altitudinal limit for the species (Baker and Cockrum 1966). These animals were taken between July 17 and October 5. A lactating female captured on August 11 suggests that some reproduction may take place in New Mexico. They are found in shortgrass plains, sactan grassland, sycamore, cotton-wood, rabbitbrush, and oak savanna. Long-nosed bats are well-known pollinators of agave, as well as saguaro, organpipe, and cardoon cacti. These bats are found primarily in desert scrub habitat in their range within the United States. They may occur at high elevations on wooded mountains in areas further south

Habitats of lesser long-nosed bats include canyons and nearby areas in desert grassland and shrublands including lower edges of oak woodlands

(Hoffmeister 1986, Findley et al. 1975; New Mexico Department of Game and Fish [NMDGF] 1996). In summer, Sanborn's long-nosed bats are found from over the desert grass-lands and scrubland up to the edge of the oaks in southern Arizona. They forage in areas of saguaro, agave, ocotillo, palo verde, and prickly pear. Where these bats are found as high as the oaks, agave and other suitable forage plants are within easy flight distance. Food is obtained from such plants as agave, saguaro, and organ pipe cactus. The bats roost in caves, mine tunnels, and occasionally old buildings. Elevations below 3,500 feet from April through July are preferred, and up to 5,500 feet from July to late September or October are the norms (Haynes and Schuetze 1997).

Comments on Food Sources: These colonial bats usually roost in caves during the day and small groups begin to emerge approximately 1 hour after sundown to feed on the nectar of plants such as agave (*Agave schottii* and *Agave palmeri*). Pollen, which is probably accidentally ingested, adds some protein to the diet. Food is obtained from such plants as agave, saguaro, and organ pipe cactus. These bats will eat the pulp of *Carnegia gigantea* and *Lemaireocereus thurberi*. Long-nosed bats in Arizona are nectar and pollen feeders. The food is obtained from such plants as agave (*Agave palmeri* and *Agave schottii*), saguaro (*Carnegia gigantea*) and organ pipe cactus (*Lemaireocereus thurberi*). The nectar has a sugar content of nearly 20 percent, and one panicle of flowers from an agave will provide 1/4 to 1/2 cup of nectar. As the bat collects nectar, much pollen accumulates on the sides of the face and body. The bat then preens itself, transferring pollen to its mouth. Pollen grains are encased in a hard shell, but the pollen will begin to germinate in the sugar of the bat's stomach (Howell 1974). Under these conditions, the pollen can be converted to amino acids, thus providing protein. The feces of Leptonycteris are like spatterings of bright yellow paint of a thin consistency, suggestive of the pollen and nectar they consume. These foods are available from blooms of saguaro in April and May, from agave through July. Bats land on the panicle of blossoms, insert the nose in blossoms within reach, and work down the series of blossoms. Sometimes they hover in front of a blossom, hummingbird-style, insert and withdraw their heads, move on to another. This bat is especially adapted for this hover flight. Vaughan (1978:101) points out that when doing this, the downward stroke of the wing is directed more forward, the upstroke backward, and the tips of the wings during the upstroke are altered from the norm. When sufficient nectar and pollen are not available, long-nosed bats may feed on the pulp and seeds of the fruit

of saguaro and organ pipe cactus. They make a small opening in the ripe fruit. Regarding the diet of lesser long-nosed bats, insects are taken at least incidentally. In Arizona, these bats have also been documented making nocturnal forays to hummingbird feeders. Nectar-feeding bats have often been recorded at hummingbird feeders in southern Arizona. Most of those in photographs were of the genus Leptonycteris. Carpenter (1969) calculated the nectar-feeding rate of these bats to be approximately 20 cubic centimeters (cc) per night per bat. The diet of the lesser long-nosed bat consists of nectar, pollen, and soft fruits of plants such as agaves and cacti with insects being taken incidentally (Hensley and Wilkins 1988; NMDGF 1996). The lesser long-nosed bat feeds mainly on agave and saguaro flower nectar and pollen (Arizona Game and Fish Department [AGFD] 1996).

Environmental Associations and Constraints: Of North America's bats, lesser long-nosed bats appear to be among the most dependent on the availability of abandoned or inactive mines. Specimens were taken in the elevational range of 1500 to 1800 m. In Arizona and New Mexico, the species occurs in desert grassland and shrubland, chaparral, and lower-elevational oak woodland and associated habitats. They are found in low elevation desert and plains grassland. Sanborn's long-nosed bats have been recorded using buildings as night roosts in Arizona. South of the United States border they sometimes are found in high elevations. Habitats of lesser long-nosed bats include canyons and nearby areas in desert grassland and shrublands including lower edges of oak woodlands (Hoffmeister 1986, Findley et al. 1975, NMDGF 1996). Sanborn's long-nosed bats in summer are found from over the desert grass-lands and scrubland up to the edge of the oaks in southern Arizona.

Comments on Adult Environmental Associations: Female lesser long-nosed bats in Arizona, from April through July, are found mostly in areas with flowering saguaros and organ-pipe cactus at elevations below about 3500 feet. Young, some females, and some late-arriving males move up to about 5500 feet in areas of semi-desert grassland and lower oak woodland in July (Monday 1993).

Comments on Breeding Adult Environmental Associations: Females are known to use rock crevices as maternity roost sites.

Comments on Feeding Adult Environmental Associations: Anecdotal reports have found that long-nosed bats feed for about 20 minutes

and then rest for an equal length of time. This is repeated numerous times, but near the middle of the night the bats retire to a structure to roost and groom.

Comments on Resting Adult Environmental Associations: These colonial bats usually roost in caves during the day and small groups begin to emerge approximately 1 hour after sundown to feed on the nectar of plants such as agave. Caves are important roost sites for lesser long-nosed bats, but they have been found roosting in trees, mines, culverts, and buildings (NMDGF 1996). In Arizona, these long-nosed bats roost during the day in mine tunnels and caves. During the night as many as 100 long-nosed bats would be resting or flying around a typical roost and maternity room at Colossal Cave, near Tucson; none was present in the daytime.

Comments on Resting Juvenile Environmental Associations: Young are left on the ceiling of the maternity colony while the mother forages at night.

Comments on Consequences of (Over) Grazing (from the Coronado National Forest Biological Opinion): The severity of adverse effects to Leptonycteris bats resulting from the potential reduction in forage resources is dependent on the importance of forage plants in a specific area to reproduction, survival, and growth of the bat. Each Environmental Management Area (EMA) discussed individually below, is considered to varying degrees as foraging habitat for the lesser long-nosed bat. Several EMAs are also known to provide appropriate roost habitat. Areas with high densities of paniculate agaves and saguaros may be particularly important to these bats, especially if those high density sites are close to roosts. The distribution of agaves across the Forest has been estimated on a landscape level by evaluating the distribution of plant communities that include bat forage plants. However, the local abundance of these forage plants has not been included in this assessment. Given the ability of the bat to move freely and widely across the landscape, the large geographic scale of the analysis may be more meaningful to assess potential effects to the lesser long-nosed bat due to impacts to its foraging habitat by livestock. The effects of the proposed action are the sum of the effects for all allotments under consideration. When an individual allotment is evaluated for effects to the lesser long-nosed bat, a “not likely to adversely affect” determination may be the result due to the bat’s mobility. However, using the EMA as the basic unit of analysis, the evaluation of effects can be

assessed at a landscape scale, similar to the way in which the bat interacts with its habitat.

The Coronado has committed to not disturbing or modifying any bat roost sites on any allotments (USFS 1998c), although the Forest does not detail how such effects will be avoided. Range project construction is also implemented so that no more than 1 percent of agaves and saguaros within 800 m (0.5 mi) of the project are affected. Undetected roosts probably occur within various allotments, possibly in each EMA. In addition, some old records of roost sites for lesser long-nosed bats have not been resurveyed for 20 or more years. Direct disturbance or modification of these roosts could occur because of range project construction or indirectly because of recreationists accessing roost sites on roads constructed or maintained as part of the grazing program.

Indirect effects from livestock grazing to Leptonycteris bats may occur through adverse effects to forage plants, primarily paniculate agaves and saguaros. Impacts to forage plants through implementation of the range management program may occur through direct herbivory and trampling by livestock, alteration of the vegetation community, degradation of soil and watershed conditions, modification of the fire regime, and range projects. The Forest has provisions in place to reduce effects to agaves from construction and maintenance activities associated with grazing management. Prescribed fire, herbicide application, and seeding of non-native plants are not part of the proposed actions. As these types of projects are proposed, they will be addressed under site-specific consultations.

Saguaros may be impacted both directly and indirectly by grazing activities. Saguaros occur on slopes, bajadas, and in valleys. Impacts due to livestock grazing activities may occur from trampling of young saguaros, grazing of nurse plants, which results in reduction or removal of protective cover, or grazing of the young saguaros themselves (Abouhalder 1992). Nurse plants, which shade sensitive saguaro seedlings, may be reduced by grazing, and germination sites may be adversely altered due to soil compaction, erosion, and reduced infiltration. Livestock seek shade under trees, and forage for annual vegetation within shrub and tree cover. Benson (1982) noted that grazing has obliterated seedbeds of saguaros. Neiring et al. (1963) found that enhanced reproduction of saguaros on slopes was correlated with reduced localized levels of grazing. Across the Forest, saguaros occur in varying densities on the lower slopes of the mountains of

the western EMAs, especially the Tumacacori and Santa Catalina EMAs. However, by mid-summer when most bats arrive on the Forest from maternity roosts farther to the west, saguaros have completed flowering and no longer provide a food source for the lesser long-nosed bat.

The primary food source for the lesser long-nosed bat in southeastern Arizona from mid-summer through fall is Palmer's agave, which typically occurs on rocky slopes or hill tops, scattered within the desert grassland and oak woodland communities within the elevation range of 900 m to 1800 m (3000 to 6000 ft; Gentry 1982). Parry's agave reaches higher elevations than Palmer's, extending from grasslands into oak woodland, chaparral, pine/oak forests, and mixed conifer with an elevation range of approximately 1500 m to 2500 m (4900 to 8200 ft; Gentry 1982). Like Palmer's agave, Parry's is typically found on rocky slopes (Gentry 1982). Concentrations of paniculate agaves are generally found on the rocky, shallow soils of hills and ridges. Palmer's and Parry's agaves are also found scattered in areas of deep, heavy soils within grasslands or where there may be thick stands of shrubs, mesquite, oak, and other trees.

The ecology of Palmer's agave appears to be poorly understood, especially as it is affected by livestock use and fire (Slauson, pers. comm., 1997; Wendy Hodgson, Desert Botanical Gardens, Phoenix, pers. comm., 1997). Agaves are perennial succulents. Agave seeds germinate readily with adequate moisture, typically in open areas with limited competition from other plants (Tony Burgess, Biosphere Two Center, Tucson, pers. comm., 1997). Palmer's agave is relatively slow growing, often taking 20 or more years before initiating the single reproductive event in its life (Slauson 1996, 1999). A flowering stalk erupts from the rosette of a mature plant, growing rapidly through the spring and early summer. During the summer 8 to 12 flowering panicles are displayed on the upper third of a stalk, 3 to 5 m (10 to 16 ft) tall (Gentry 1982). Slauson (1996, 1999) has completed a pollination ecology study of Palmer's agave, finding that many pollinator species contribute to establishing seed set. Lesser long-nosed bats have been recorded visiting individual blooming Palmer's agave more than 1000 visits per night (R. Sidner, Tucson, pers. comm., 1997; Petryszyn, pers. comm., 1999), while they may not visit other agaves at all (Slauson, pers. comm., 1997). Bat visits generally last less than 1 second (Slauson 1999). Apparently there are many factors that influence the year a particular plant may bloom. Precipitation 1 to several years before blooming is probably of special importance. In the Peloncillo Mountains, about 2 to 5

percent of the agave population flowers each year (Peter Warren, Nature Conservancy, Tucson, pers. comm., 1997). Palmer's agave may occasionally produce off-sets (vegetative reproduction or cloning of "pups" produced from rhizomes) though this is less likely than for many other agave species (Hodgson, pers. comm., 1997). Parry's agave freely produces offsets (Gentry 1982).

The importance of Parry's agave, as well as desert agave and amole, as a forage resource for Leptonycteris bats is unknown. As discussed, Parry's agave generally occurs at higher elevation than Palmer's agave, and occurs in forest openings. Benson and Darrow (1982) note that it typically flowers in June and early July, which is before the lesser long-nosed bat arrives at roosts in southeastern Arizona. However, J. Rorabaugh (Arizona Ecological Services Field Office, pers. comm., 1998) noted many Parry's agave in flower high in the Huachuca Mountains on the crest trail during late July in 1997. It may be that agaves at high elevation bloom later than at lower sites, and could potentially be blooming and be used as a forage resource when lesser long-nosed bats arrive in July or early August. In addition, Parry's agave may be very important as a forage plant for those bats that arrive in southeastern Arizona during late spring and early summer.

No long-term investigation has quantitatively documented the effect of grazing on agave mortality or flowering stalk herbivory. Individual paniculate agave plants only bloom once in their life of about 20 years. However, agave stalks are rich in carbohydrates, and as they begin to bolt they are particularly palatable to domestic livestock and wild herbivores, including deer, javelina, rodents, and rabbits (Howell 1996; M. Hawks, University of Arizona, pers. comm., 1997; Hodgson, pers. comm., 1997). The desirability of these stalks in early spring is likely influenced by availability of quality forage in the area. Under conditions of inadequate precipitation to facilitate a spring green-up, especially when high levels of utilization are reached or following range fires, cattle as well as local wildlife may seek out agave stalks (Tricia Roller, Arizona Ecological Service Field Office, pers. comm., 1997; Fehmi et al. 2004). Cattle have been known to "walk down" agave flowering stalks (T. Cordery, Arizona Ecological Services Field Office, pers. comm., 1998). Cattle probably trample young agaves, causing some level of mortality among these plants. Agave germination and seedling establishment may be influenced by degraded ecological conditions such as soil compaction, erosion, reduced infiltration, and altered plant species composition. Effects on bat forage plants due to livestock

grazing are expected to be more intense where livestock congregate near water sources and less intense on steep slopes or among rocks where grazing is generally lighter and agaves are at higher densities.

Livestock management practices (past and present) and non-native plant introductions have contributed to changes in the natural dynamics and composition of vegetation communities (Fleischner 1994), as has past fire control policies. For an overview of livestock management effects to natural ecosystems see the general effects discussion earlier in the biological opinion. How past land management activities have affected the agave distribution and abundance present today is unclear, as are the potential effects of fire in an altered system.

Effects of livestock grazing on fire frequency and intensity, and subsequent effects to agave and floral resources for bats are complex. Before about 1900, widespread surface fires occurred in the Madrean borderlands. These frequent ground fires ceased to occur about the time intensive livestock grazing began (Swetnam and Baisan 1996). Although other factors likely played some role in the elimination of frequent ground fires, most authors agree that livestock grazing was probably the most important factor, at least before effective fire suppression began in the 1930s (Bahre 1991, 1995; Swetnam and Baisan 1996; Danzer et al. 1997). Livestock grazing removes dried herbaceous fine fuels that normally carry fire. Without fire, ladder fuels and woody material build up in woodlands. The result is that when fires finally do occur, they can be catastrophic and stand-replacing (Danzer et al. 1997). How this change in fire frequency and intensity caused in part by livestock grazing effects agave populations is unknown. In the absence of frequent ground fires, agave populations could potentially benefit due to reduced mortality resulting from fire. However, infrequent intense fires could kill greater percentages of agaves when fires occur, if agaves are growing amid brush or other areas of high fuel loads.

Other factors are important in determining the effects of livestock grazing on fire regimes and subsequent effects to agaves and floral resources. Activities that directly or indirectly promote invasions or increased density of nonnative grasses, particularly Lehmann lovegrass, may result in increased fire frequency or intensity, reduced densities of Palmer's agave, and thus reduced floral resources for the lesser long-nosed bat. Lehmann lovegrass is abundant in some portions of the Forest, especially the Tumacacori, Huachuca, Santa Rita, and Santa Catalina EMAs and its relative

abundance has been positively correlated with livestock grazing intensities (Anable et al. 1992, McClaran and Anable 1992). This species increases after fire (Martin 1983, Ruyle et al. 1988, Sumrall et al. 1991, Howell 1996), but also produces an abundance of fine fuel that promotes hot fires (McPherson 1995). Thus, frequent fire is likely to increase the abundance of Lehmann lovegrass, and increased abundance of this grass can fuel more fires and hotter fires, creating a positive feedback loop (Anable et al. 1992). Frequent, hot fires caused by prescribed fires and increasing prevalence of Lehmann lovegrass could reduce densities of Palmer's agave. In an ungrazed setting at Fort Huachuca, Howell (1996) found that Lehmann lovegrass creates areas of continuous fuels that burn at a constant temperature versus stands of native grasses that are patchy regarding fuels and fire intensity. Agaves can persist in fire-prone native grasslands in bare areas or refugia that burn lightly or not at all. Such refugia are less common in Lehmann lovegrass stands. Howell (1996) also noted a negative relationship between the proportion of agave seedlings and ramets and the amount of Lehmann lovegrass. She suggested that Lehmann lovegrass appears to suppress agave recruitment independent of the fire effects just described. The mechanism of suppression is unclear, but Howell (1996) suggests Lehmann lovegrass may compete effectively with agaves for nutrients, moisture, or light. If agave densities are reduced due to elevated fire effects or recruitment suppression caused by Lehmann lovegrass invasion, forage resources of the lesser long-nosed bat will be reduced. Agaves in desert grasslands have evolved with fire, but unnatural, high fire frequency can lead to decline or elimination of agave populations (Howell 1996). Howell (1996) found that a fire frequency of three to six per decade on Fort Huachuca is "clearly too high to allow sexual reproduction to persist in the agave community... too high to permit seedling establishment and too high to allow even the fast growing clones to achieve reproductive status."

Agave mortality due to fire may affect the abundance and distribution of blooming agaves on the landscape for many years into the future, especially if there is high mortality within certain age and size classes. Although fire may affect the availability of blooming agaves, the nectar production and sugar content of surviving plants is little effected. Working in the Peloncillo Mountains, Slauson et al. (1998) found that nectar production and sugar content did not differ between unburned agaves and burned agaves that did not have greater than 80 to 90 percent of the leaf area burned. The complexity of variables influencing agave flowering may

mask the effects of a fire on agave flowering for several years after a fire. In addition, natural recruitment of agaves may be very episodic and the effects of fire on the agave seed bank in the soil are unknown. Livestock grazing, especially at high utilization levels, often promotes the increase of non-native and less-palatable species, which may influence the resulting fire regime. Often the objectives of livestock management are to increase the abundance of grasses while the direct impacts of livestock herbivory are the reduction of grass cover. Grasses are probably one of the strongest competitors with agave seedlings (Burgess, pers. comm., 1997). Increased abundance of grass could result in reduced agave abundance. When overgrazing results in declines of perennial grasses (Martin and Cable 1974, Eckert and Spencer 1987), there may be less competition between grasses and agaves. However, there may also be increased trampling of smaller agaves by livestock, and increases in woody/shrub vegetation results in an altered fire regime.

The factors that are important to Leptonycteris bats are the availability of agave flowering stalks, each and every year. In southeastern Arizona, Palmer's and Parry's agaves are the only reliable food source for long-nosed bats in mid to late summer. However, agaves are patchily distributed over the landscape and the presence of flowering agaves naturally fluctuates from year to year. Nectar-feeding bats are opportunistic foragers, taking advantage of local floral resources. During the breeding season lesser long-nosed bats may fly great distances in search of food resources, and later in the season they may shift roost sites and foraging areas based on the presence (or absence) of flowering agaves (Petryszyn, pers. comm., 1997). The distance the bats will forage from a roost site appears to be related to the size of the colony and the available floral resources (V. Dalton, pers. comm., 1997; Petryszyn, pers. comm., 1997). Lesser long-nosed bats are generally present in southeastern Arizona after the bats have left their maternity colonies and migrated to southeast Arizona and southwest New Mexico in mid to late summer when agaves are in flower.

Effects to Leptonycteris bats occur through direct herbivory and trampling of agaves, alterations of species composition of the community, disruption of ecosystem functions, alteration of ecosystem structure, and the related effects on agaves. Agaves have persisted on the landscape (and sometimes may have even increased) over the course of more than a century of livestock use on the landscape. A major concern is the frequency of drought conditions in the Southwest. Overgrazing often accompanies drought con-

ditions when stocking levels cannot be quickly reduced to match the limited forage production. Periodic overgrazing can damage range resources (Eckert and Spencer 1987) and have long-term negative effects.

Grazing utilization levels over 40 percent are considered damaging to the ecosystem (Martin 1975, Eckert and Spencer 1987, Holechek et al. 1998). How these or other specific levels of utilization are directly correlated to effects on agaves is not known. However, as utilization levels or stocking levels increase, effects to the vegetation community and agaves also increase. No information is available on the relationship of grazing management systems and utilization levels to the associated effects on agaves. The Forest has initiated and is committed to completing a multi-year study on agave ecology and the relationships to livestock management. This type of information is needed to make fully informed decisions regarding the effects of livestock management to the lesser long-nosed bat. Until this information is available, the Forest should be careful not to preclude management and conservation options for the bat. The effects that livestock are having today on the landscape are manifest in changes in the ecosystem for years and decades to come. The effects of livestock use today on seedling agaves will not be manifest to the bat for 20 or more years, when those plants would be reaching maturity and bolting. The effect of livestock today due to herbivory on bolting agaves, results in immediate reductions of forage resources available to Leptonycteris.

Central to the issue of evaluating adverse effects due to livestock impacts to forage plants of post-breeding Leptonycteris bats is the question, are agave floral resources potentially limiting to the bat? This was a major topic of a meeting among the Forest, Service, and consultation applicants early in 1999. Various bat and agave species experts participated in this meeting. Though there were many perspectives on this subject, one answer appears clear: there are very little data. Limited information is available on bat foraging ecology and energetics, as well as the relation of livestock use to agave mortality, and weather parameters to agave bolting. Though many, many paniculate agaves are present across the landscape, it is not understood if all these are equally available and desirable to the bat. Slauson (pers. comm, 1999) believes that agave nectar is not limiting to lesser long-nosed bats. This conclusion is based on her pollination biology study of Palmer's agave (Slauson 1999) in which bat visitation and quantities of available nectar were monitored. Nighttime observations were conducted at several sites for a total of over 15 hours of periodic observations. In ad-

dition, floral nectar was always abundant at her sites and not depleted by pollinators. Slauson (1999) discussed possible factors related to the lack of observed bat visitations: (1) during stormy or windy weather, bat foraging distances and activity may decrease; (2) sufficient food resources for the number of bats present may have been available closer to the roost; and (3) other foraging sites may have been preferred. Some of the observation sites were in areas where Leptonycteris bats are widely dispersed. The relationship of foraging areas to roost sites, especially large roosts, is important in land management decisions. Availability of large roost sites is considered a major limiting factor to the bats (USFWS 1997). Affecting forage resources in proximity to roosts may affect a substantial portion of the bat population in Arizona, and may affect the desirability of a particular roost site.

In summary, superimposing the potential effects of livestock use as it affects the availability of floral resources, adult plant mortality, and seedling mortality, upon the natural variability in agave phenology, episodic reproductive events, and patchy distribution on the landscape, grazing may affect agaves and nectar feeding bats in a variety of ways. Leptonycteris bats are opportunistic foragers and are capable of long distance flights. Temporary and minor shifts in the abundance of flowering agaves as an available resource for these bats are expected to have limited adverse effects. However, as these impacts to lesser long-nosed bat food resources occur across large portions of the landscape, as analyzed through the EMAs on the Coronado NF, bat survivorship may be reduced through increased foraging flight distances and related energy expenditures, increased exposure to predators, changes in use patterns of limited large roost sites, and potential disruption of the “nectar corridor.” These effects may be most evident in those years where weather patterns, fire, or other causes have also affected agaves. The long-term effect of livestock use contributes to ecosystem based changes. The net result is that there are effects from livestock activities across the landscape to the ecosystem upon which the lesser long-nosed bat depends. Exactly how this alters the distribution and abundance of agaves, and to what degree this may impact lesser long-nosed bat populations is uncertain.

Army Installations Concerned

Only Fort Huachuca, Sierra Vista, AZ, reported in the 2000 survey that the lesser-long nosed bat was found on their property. Two other, smaller sites operated by the Arizona Army National Guard reported that the bat was

known to be found on property contiguous to their lands. These were the Florence Military Reservation, Florence, AZ, and the Marana (Silver Bell) Army Heliport, Marana, AZ.

Executive Summary of Lesser Long-Nosed Bat Recovery Plan

U.S. Fish and Wildlife Service, 1997[2]

Recovery Objective: Reclassification (downlisting) to threatened.

Recovery Criteria: The Fish and Wildlife Service should review the status of the lesser long-nosed bat to determine if reclassification to threatened is warranted if all the following criteria are met: (1) each major roost population in Arizona and Mexico is monitored for at least 5 years; (2) the results of that monitoring show that population numbers are stable or increase over the higher set of population figures appearing in this recovery plan; (3) sufficient progress has been made in the protection of roosts and forage plants from disturbance or destruction; (4) no new threats to the species or its habitat have been identified or there are no increases to currently recognized threats; and (5) the Service determines the species is no longer endangered.

Actions Needed for Recovery:

1. Continue protecting roost sites and evaluate the need for and implement protection for food plants.

2. Monitor all major roosts in Arizona, New Mexico, and Mexico once a year.

3. Continue surveying for additional roosts in the United States and Mexico.

4. Develop and conduct a public education and information campaign in Arizona, New Mexico, and Mexico on the beneficial aspects of bats in general and the lesser long-nosed bat specifically.

5. Conduct critical research on population census techniques, physical requirements for roosts, foraging ranges of roosts, reproduction and mating systems and other life history and habitat questions.

[2] USFWS, 1997. Lesser long-nosed bat recovery plan. Albuquerque, New Mexico. 49pp.

Date of Recovery: If the recovery criteria can be met, downlisting to threatened may be possible relatively soon. Delisting criteria will not be developed until after the species has been downlisted to threatened.

Relation to Military Uses

While the discussion above relates almost entirely to the effects of grazing domestic livestock on National Forest lands, one cannot help but note the many similarities to aspects of military use, including especially the disturbance, trampling, promotion of invasive species, change in fire frequency, and decrease in agave populations. Thus, in a qualitative sense, grazing is almost a surrogate for military training in this environment. We note that a study of the grazing of Agave inflorescences was performed in 2003 at Fort Huachuca (Fehmi, et al. 2004), and concluded that ungulates other than livestock, i.e. deer, were responsible for much of the loss. It was speculated that this may have been due to a marked decrease in public access for hunting following the September 11, 2001 attacks.

References

References cited in this chapter and selected additional sources for more information.

From FWS[3]

53 Federal Register (FR) 38456. September 30, 1988.

70 FR 5460, February 2, 2005.

Abouhalder, F. 1992. Influence of livestock grazing on saguaro seedling establishment. Pages 57-61 in Stone, C.P., and E.S. Bellantoni, eds., Proceedings of the Symposium on Research in Saguaro National Monument, Tucson.

Anable, M.E., M.P. McClaran, and G.B. Ruyle. 1992. Spread of introduced Lehmann lovegrass Eragrostis lehmanniana Nees. in southern Arizona, USA. Biol. Cons. 61:181-188.

Arita, H.T., and S.R. Humphrey. 1988. Revision taxonomica de los murcielagos magueyeros del genero Leptonycteris (Chiroptera: Phyllostomidae). Acta Zool. Mexicana, n.s., 29:1-60.

Arizona Game and Fish Department. 1988. Threatened native wildlife in Arizona. Arizona Game and Fish Dept. Publication, Phoenix. 32pp.

Arizona Game and Fish Department. March 16, 1996. Wildlife of Special Concern in Arizona (Public Review DRAFT). Phoenix, AZ, 85023-4399. Heritage Data Management System.

Arizona Game and Fish Dept., 1998 Nongame Branch, Phoenix. Heritage Data Management System.

Bahre, C.J. 1991. A legacy of change: Historic human impact on vegetation of the Arizona borderlands. University of Arizona Press, Tucson. 231pp.

Bahre, C.J. 1995. Human impacts on the grasslands of Southeastern Arizona. Pages 230-264 in McClaran, M.P., and T.R. Van Devender eds., The Desert Grassland, University of Arizona Press, Tucson.

Bailey, V. 1931. Mammals of New Mexico. North Amer. Fauna. 53:1-412.

Baker, Robert J. and E. Lendell Cockrum. 1966. Geographic and Ecological Range of the Long-Nosed Bats, Leptonycteris. *Journal of Mammalogy*, Vol. 47 pp. 329-331

Barber, C.M. 1902. Notes on little known New Mexican mammals and species apparently not recorded from the territory. Proc. Biol. Soc. Wash. 15:191-193.

[3] This set of references is from the Biological Opinion on grazing allotments on the Coronado National Forest, dtd 29 Jul 1999.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing and the riparian zone: Impact and management perspectives. In Johnson, R.R., and J.F. McCormick, tech. coords., Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems: A Symposium. USDA Forest Service, Gen. Tech. Rep. WO-12, Washington, D.C.

Belnap, J. 1992. Potential role of cryptobiotic soil crusts in semiarid rangelands. Paper presented at the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands, Boise, Idaho, May 18-22, 1992.

Belsky, A.J. 1986. Does herbivory benefit plants? A review of the evidence. American Naturalist 127(6):870-892.

Belsky, A.J. and D.M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the interior west. Conservation Biology 11(2):315-327.

Benson, L. 1982. The cacti of the United States and Canada. Stanford Univ. Press, Stanford, California.

Benson, L. and R.A. Darrow. 1982. Trees and shrubs of the Southwestern deserts. University of Arizona Press, Tucson.

Blackburn, W.H. 1984. Impacts of grazing intensity and specialized grazing systems on water-shed characteristics and responses. Pages 927-983 in Developing Strategies for Range-land Manage., Nat'l. Research Council/Nat'l. Acad. Sci., Westview Press, Boulder, Colo.

Blydenstein, J., C.R. Hungerford, G.I. Day, and R.R. Humphrey. 1957. Effect of domestic livestock exclusion on vegetation in the Sonoran Desert. Ecology 38:522-526.

Bock, C.E., and J.H. Bock. 1994. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. J. Range Manage. 37:239-242.

Brown, D.E. 1982. Biotic communities of the American Southwest--United States and Mexico. Desert Plants 4:123-181.

Brown, J.H., and W. McDonald. 1995. Livestock grazing and conservation on Southwestern rangelands. Conservation Biology 9(6):1644-1647.

Burgess, R.L. 1964. Preliminary reports on the botany of Tonto National Monument. II. Quantitative analysis of the saguaro population. Unpublished Report. 99pp.

Carpenter R.E. 1969. Structure and function of the kidney and the water balance of desert bats. Physiol Zool 42:288–302.

Caughley, G., and A. Gunn. 1996. Conservation biology in theory and practice. Blackwell Science Inc., United States. 459pp.

Cockrum, E.L., and Y. Petryszyn. 1991. The lesser long-nosed bat. Leptonycteris: An endangered species in the Southwest? Texas Tech Univ., Occassional Papers the Museum, Number 142.

Dahlem, E.A. 1979. The Mahogany Creek watershed - with and without grazing. Pages 31-34 in Cope, O.B., ed., Forum — Grazing and Riparian/Stream Ecosystems, Trout Unlimited, Denver, Colorado.

Dalton, V.M., D.C. Dalton, and S.L. Schmidt. 1994. Roosting and foraging use of a proposed military training site by the long-nosed bat, Leptonycteris curasoae. Report to the Luke Air Force Natural Resources Program, Contract Nos. DACA65-94-M-0831 and DACA65-94-M-0753. 34pp.

Danzer, S.R., C.H. Baisan, and T.W. Swetnam. 1997. The influence of fire and land-use history on stand dynamics in the Huachuca Mountains of southeastern Arizona. Appendix D in Robinett, D., R.A. Abolt, and R. Anderson, Fort Huachuca Fire Management Plan, Report to Fort Huachuca.

Dobyns, H.F. 1981. From fire to flood: Historic human destruction of Sonoran Desert riverine oases. Ballena Press, Socorro, New Mexico. 222pp.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. Freeman Press, San Francisco, California.

Eckert, R.E., and J.S. Spencer. 1987. Growth and reproduction of grasses heavily grazed under rest-rotation management. J. Range Management 40(2):156-159.

Ehrlich, P.R. 1983. Genetics and the extinction of butterfly populations. Chapter 9 in Schonewald-Cox, C.M., S.M. Chambers, B. MacBryde, and L. Thomas, eds., Genetics and Conservation.

Ellison, L. 1960. Influence of grazing on plant succession on rangelands. Botanical Rev. 26(1):1-78.

Fehmi, J.S., S. Danzer, and J. Roberts. Agrave Palmeri Inflorescence Production on Ft. Huachuca, Arizona. 2004. TR-04-16. Construction Engineer Research Laboratory, Champaign, IL USA.

Findley, J.S., A.H. Harris, D.E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque. 360pp.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8(3):629-644.

Fleming, T.H., R.A. Nunez, and L.S.L. Sternberg. 1993. Seasonal changes in the diets of migrant and non-migrant nectarivorous bats as revealed by carbon stable isotope analysis. Oecologia 94:72-74.

Gentry, H. S. 1982. Agaves of Continental North America. University of Arizona Press, Tucson. 670pp

Glinski, R.L. 1977. Regeneration and distribution of sycamore and cottonwood trees along Sonoita Creek, Santa Cruz County, Arizona. Pages 116-123 in Johnson, R.R., and D.A. Jones, eds., Importance, Preservation, and Management of Riparian Habitats: A Symposium, USDA Forest Service, Gen. Tech. Rep. RM-43, Rocky Mtn. For. & Range Exp. Stn., Ft. Collins, Colorado. 217pp.

Hadley, D., and T.E. Sheridan. 1995. Land use history of the San Rafael Valley, Arizona (1540-1960). USDA Forest Service, General Technical Report, RM-GTR-269, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado. 279pp.

Hanski, I., and M. Gilpin. 1991. Metapopulation dynamics: A brief history and conceptual domain. Biological J. of the Linnean Society 42:3-16.

Harper, K.T., and J.R. Marble. 1988. A role for nonvascular plants in management of arid and semiarid rangelands. Pages 137-169 in Tueller, P.T., ed., Vegetation Science Applications for Rangeland Analysis and Management, Kluwer Academic Publishers, Boston.

Hastings, J.R., and R.M. Turner. 1965. The changing mile: An ecological study of the vegetation change in the lower mile of an arid and semiarid region. University of Arizona Press, Tucson. 317pp.

Hastings, J.R., and R.M. Turner. 1980. The changing mile. University of Arizona Press, Tucson. 327pp.

Haynes, Lisa and Susan Schuetze. 1997. Pamphlet: A Sampler of Arizona's Threatened and Endangered Wildlife, Arizona Game and Fish Department and Arizona Department of Agriculture.

Hayward, B., and E. L. Cockrum. 1971. The natural history of the western long-nosed bat, Leptonycteris sanborni. West. New Mexico Univ., Res. Sci. 1:75-123.

Hayward, B., E.J. Heske, and C.W. Painter. 1997. Effects of livestock grazing on small mammals at a desert cienega. J. Wildl. Manage. 61(1):123-129.

Hedrick, P.W., and K.M. Parker. 1999. Genetic characterization of Sonoran topminnow populations. Arizona State University, Dept. of Biology, Tempe. 13pp.

Hendrickson, D.A., and W.L. Minckley. 1984. Cienegas-vanishing climax communities of the American Southwest. Desert Plants 6(3):131-175.

Hensley, A. P. and K. T. Wilkins. 1988. Leptonycteris nivalis. Mammalian Species 307:1–4.

Hoffmeister, D.F. 1957. Review of the long-nosed bats of the genus Leptonycteris. J. Mammal. 38:454-461.

Hoffmeister, D.F. 1986. Mammals of Arizona. University of Arizona Press, Tucson.

Holechek, J.L. 1999. On Going and Long-Term Grazing in the Coronado National Forest: Memorandum to William N. Poorten. New Mexico State University, Las Cruces. 2pp.

Holechek, J.L., J. Hawkes, and T. Darden. 1994. Macro-economics and cattle ranching. Rangelands 16:118-123.

Holechek, J.L., R.D. Pieper, and C.H. Herbel. 1998. Range management: Principles and practices. Prentice Hall Publishers, New Jersey.

Horner, M.A., T.H. Fleming, and M.D. Tuttle. 1990. Foraging and movement patterns of a nectar feeding bat: Leptonycteris curasoae. Bat Research News 31:81.

Howell D. J. 1974. Bats and pollen: physiological aspects of the syndrome of chiropterophily. Comp. Biochem. Physiol. 48 A:263–276.

Howell, D.J. 1996. Agave palmeri on Fort Huachuca: Five years of research on natural history and response to fire. Report to Fort Huachuca, Arizona.

Hoyt, R.A., J.S. Altenbach, and D.J. Hafner. 1994. Observations on long-nosed bats (Leptonycteris) in New Mexico. Southwestern Naturalist 39:175-179.

Hughes, L.E. 1979. Rest-rotation grazing vs. season long grazing on Naval Oil Shale Reserve Allotment in Colorado. Rangelands 1(2):55-56.

Humphrey, R.R. 1958. The desert grassland; a history of vegetational change and an analysis of causes. Botanical Review 24:193-252.

Hunter, M.L., Jr. 1996. Fundamentals of conservation biology. Rand McNally, Taunton, Massachusetts. 482pp.

Jahrsdoerfer, S.E., and D.M. Leslie, Jr. 1988. Tamaulipan brushland of the Lower Rio Grande Valley of South Texas: Description, human impacts, and management options. US Fish and Wildlife Service, Biol. Rep. 88(36). 63pp.

Jameson, D. A. 1963. Responses of individual plants to harvesting. Botanical Rev. 29:532-594.

Laurenson, L.B.J., and C.H. Hocutt. 1985. Colonization theory and invasive biota: The Great Fish River, a case history. Environmental Monitoring and Assessment 6(1985):71-90.

Leopold, L.B. 1951. Vegetation of southwestern watersheds in the nineteenth century. The Geographical Review 41:295-316.

Loft, E.E., J.W. Menke, and J.G. Kie. 1991. Habitat shifts by mule deer: The influence of cattle grazing. J. Wildl. Manage. 55(1):16-26.

Loft, E.E., J.W. Menke, and J.G. Kie and R.C. Bertram. 1987. Influence of cattle stocking rate on the structural profile of deer hiding cover. J. Wildl. Manage. 51(3):655-664.

Lusby, G.C. 1979. Effects of grazing on runoff and sediment yield from desert rangeland at Badger Wash in western Colorado, 1953-73. US Geological Survey, Water Supply Paper 1532-D.

MacArthur, R.H., and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.

Martin, S.C. 1973. Responses of semi-desert grasses and shrubs to fall burning. J. Range Manage. 36:604-610.

Martin, S.C. 1975. Ecology and management of southwestern semidesert grass-shrub ranges: The status of our knowledge. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 39pp.

Martin, S.C. 1978. Responses of semidesert grasses to seasonal rest. J. Range Manage. 26:165-170.

Martin, S.C. 1983. Responses of semi-desert grasses and shrubs to fall burning. Journal of Range Management 36:604–610.

Martin, S.C. and D.R. Cable. 1974. Managing semi-desert grass-shrub ranges: Vegetation responses to precipitation, grazing, soil texture, and mesquite control. USDA Agric. Tech. Bull. 1480.

McClaran, M.P., and M.E. Anable. 1992. Spread of introduced Lehman lovegrass along a grazing intensity gradient. J. of Applied Ecology 29:92-98.

McPherson, G. 1995. The role of fire in desert grasslands. Pages 130-151 in McClaran, M.P., and T.R. Van Devender eds., The Desert Grassland, Univ. of Ariz. Press, Tucson. 346pp.

Mead, J.I. 1975. The 1975 field season faunal remains from the Lehner Site, Arizona. Report to University of Arizona, C.V. Haynes, Dept. of Anthropology, Tucson.

Minnich, R.A. 1994. Postfire succession in desertscrub communities of southern California. Pages 93-112 in Fletcher-Jones, A., ed., Proc. of the Desert Tortoise Council Symposium.

Monday, Charone D., Editor. 1993. Arizona Wildlife Views - Special Heritage Edition: Bats of Arizona. Arizona Game and Fish Department. Volume 36, No.8. 36pp.

Mosconi, S.L., and R.L. Hutto. 1981. The effect of grazing on land birds of a western Montana riparian habitat. Pages 221-233 In Peek, J.M., and P.H. Dalke, eds., Symposium on Wildlife-livestock Interactions, Univ. of Idaho, Moscow.

Moyle, P. B., and J. E. Williams. 1990. Biodiversity loss in the temperate zone: Decline of the native fish fauna of California. Conservation Biology 4(3):275-284.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 16, 2006).

New Mexico Department of Game and Fish, Spring 1996. Threatened and Endangered Species of New Mexico -- 1996 Biennial Review and Recommendations. Authority: Wildlife Conservation Act (NMSA 17-2-37 through 17-2-46, 1978).

Niering, W.A., R.H. Whittaker, and C.H. Lowe. 1963. The saguaro: A population in relation to environment. Science 142:15-23.

Ockenfels, R.A., D.E. Brooks, and C.H. Lewis. 1991. General ecology of Coues white-tailed deer in the Santa Rita Mountains: A final report. Arizona Game and Fish Dept., Research Branch Tech. Rep. #6, Phoenix.

Orodho, A.B., M.J. Trlica, and C.D. Bonham. 1990. Long-term heavy grazing effects on soil and vegetation in the four corners region. Southwestern Naturalist 35(1):9-15.

Painter, C. 1995. Species accounts for each of the species currently listed as Federal or State endangered, threatened, or notice-or-review species. New Mexico Game and Fish Dept., Santa Fe, New Mexico.

Pase, C.P., and D.E. Brown. 1982. Rocky Mountain and Madrean montane conifer forest. Pages 43-48 in Brown, D.E., ed., Biotic Communities of the American Southwest, Desert Plants 4(1-4).

Peterson, L.A. 1999. Letter to Fish and Wildlife Service on Biological opinion draft for the Red Rock Ranch, May 4, 1999. US Fish and Wildlife Service, Phoenix. 42pp.

Postovit, H.R., and B.C. Postovit. 1987. Impacts and mitigation techniques. Pages 183-213 in Giron Pendleton, B.A., B.A. Milsap, K.W. Cline, and D.M. Bird, eds., Nat'l. Wildl. Fed., Raptor Management Techniques Manual, Scientific Tech. Series 10, Washington, D.C.

Ragoztkie, K.E., and J.A. Bailey. 1991. Desert mule deer use of grazed and ungrazed habitats. J. Range Manage. 44(5):487-490.

Range Term Glossary Committee, Society for Range Management, M.M. Kothmann, Chairman. 1974. A glossary of terms used in range management, second ed., Belke Printing Company, Denver, Colorado. 36pp.

Roller, P.S. 1996. Distribution, growth and reproduction of Pima pineapple cactus (Coryphantha scheeri Kuntz var. robustispina Schott). MS Thesis, Univ. Ariz., Tucson.

Roller, P.S. and W.L. Halvorson. In press. Fire and Pima pineapple cactus (Coryphantha scheeri var. robustispina) in southern Arizona. In Proceedings of the Effects of Fire on Threatened and Endangered Species Symposium, November 1995, Coeur d'Alene, Idaho.

Ruyle, G.B., B.A. Roundy, and J.R. Cox. 1988. Effects of burning on germinability of Lehmann lovegrass. J. of Range Management 41:404-406.

Sahley, C.T., M.A. Horner, and T.H. Fleming. 1993. Flight speeds and mechanical power outputs in the nectar feeding bat, Leptonycteris curasoae (Phyllostomidae: Glossophaginae). J. Mammal. 74:594-600.

Saucedo Monarque, E. 1990. Proyecto: Prospeccion de plantas raras en el Norte de Sonora. Centro Ecologico de Sonora, Subdireccion de Investigacion, Area de Ecologia Terrestre, Hermosillo, Sonora, Mexico. 65pp.

Schlesinger, W.H., J.F. Reynolds, G.L. Cunningham, L.F. Huenneke, W.M. Jarrell, R.A. Virginia, and W.G. Whitford. 1990. Biological feedbacks in global desertification. Science 246:1043-1048.

Schmidly, D. J. 1977. The mammals of Trans-Pecos Texas including Big Bend National Park and Guadalupe Mountains National Park. Texas A&M University Press, College Station.

Schmutz, E.M. 1977. Seasonal grazing systems for southwestern ranges. Univ. of Arizona, Bulletin No. Q381, Tucson.

Shafer, C.L. 1990. Nature reserves, island theory and conservation practice. Smithsonian Institution Press, Washington D.C. 189pp.

Shifflett, W.A. 1987. Habitat suitability on the Coronado National Forest adjacent to the Buenos Aires National Wildlife Refuge. Letter to Larry Allen, Coronado National Forest, Supervisor's Office, Tucson, Arizona, June 17, 1987. 1pp + map.

Shreve, F. 1931. Physical conditions in sun and shade. Ecology 12:96-104.

Sidner, R. 1993. Fourth annual monitoring of potential roost sites of the lesser long-nosed bat (Leptonycteris curasoae) on the Fort Huachuca Military Reservation, Cochise County, Arizona. Report to Fort Huachuca, Contract #DABT63-93-P-0597, Arizona.

Sidner, R. 1994. Bat inventory of riparian areas of the Fort Huachuca Military Reservation 1993-1994. Rep. to Ariz. Game & Fish Dept., Heritage Fund, IIPAM Project #I92019. 47pp.

Sidner, R. 1996. Sixth annual monitoring of potential roost sites of the lesser long-nosed bat (Leptonycteris curasoae) and other bat species on the Fort Huachuca Military Reservation, Cochise County, Arizona. Rep. to Ft. Huachuca, Contr. #DABT63-95-P-1083, Arizona.

Sidner, R. 1997. Eighth annual monitoring of the lesser long-nosed bat (Leptonycteris curasoae) and other species of bats with emphasis on roost sites on the Fort Huachuca Military Reservation, Cochise County, Arizona, May-October, 1997 (draft). Report to Fort Huachuca, Contract #DABT63-97-P-0623, Arizona.

Silvertown, J.W. 1982. On evolved mutualism between grasses and grazers. Oikos 38:253-259.

Slauson, L. 1996. Pollination ecology of Agave chrysantha and Agave palmeri. Pages 154-203 in Amorphametric and Pollination Ecology Study of Agave chrysantha Peebles and Agave palmeri Englem. (Agavaceae). Ph.D. Diss., Arizona State University, Tempe.

Slauson, L. 1999. Pollination biology of two chiropterophilous agaves in Arizona, Draft. Desert Botanical Garden, Phoenix.

Slauson, L., G. Dalton, and D. Dalton. 1998. Effects of prescribed burning on the Palmer agave and lesser long-nosed bat. Research Joint Venture Agreement No. 28-JV7-943.

Smith, E.L., P.R. Ogden, J.G.G. Soares, R.A. de Luna, and D.D. Young. 1993a. Seasonal diets of cattle on hot desert rangelands. Pages 129-143 in Symposium on Vegetation Management of Hot Desert Rangeland Ecosystems, July 28-30, 1993, Phoenix.

Smith, E.L., P.R. Ogden, and H. deSouza Gomes. 1993b. Forage preference and grazing behavior of hereford and barzona cattle on a southern Arizona range. Pages 144 - 154 in Symp. on Vegetation Management of Hot Desert Rangeland Ecosystems, July 28-30, 1993, Phoenix.

Snow, C. 1973. San Joaquin kit fox, Vulpes macrotis mutica and related subspecies, and the swift fox, Vulpes velox. USDI, Bur. Land Manage. Tech. Note No. 238. 24pp.

Soule, M.E. 1986. Conservation Biology: The science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, Massachusetts. 584pp.

Southwest Center for Biological Diversity. 1995. Grazing abstracts. Working draft, August 22, 1995, Tucson.

Southwest Center for Biological Diversity. 1999. Grazing bibliography: Database. Http://www.sw-center.org/swcbd/grazing/ grazingbib.htm.

Southwood, T.R.E. 1961. The numbers of species of insects associated with various trees. J. Animal Ecol. 30:1-8.

Sprunt, A. 1955. North American birds of prey. National Audubon Society, Harper and Brothers, New York. 227pp.

Steenbergh, W.F., and C.H. Lowe. 1977. Ecology of the Saguaro: II. Reproduction, germination, establishment, growth, and survival of the young plant. US National Park Service, Monograph Series Number 8, US Government Printing Office, Washington, DC.

Stefferud, J. 1999. E-mail memorandum Re: Redrock Canyon, June 3, 1999. USDA Forest Service, Phoenix. 1pp.

Sumrall, L.B., B.A. Roundy, J.R. Cox, and V.K. Winkel. 1991. Influence of canopy removal by burning or clipping on emergence of Eragrostis lehmanniana seedlings. International J. of Wildland Fire 1:35-40.

Swetnam, T.W., and C.H. Baisan. 1996. Fire histories of montane forests in the Madrean borderlands. Pages 15-36 in Ffolliott, P.F., L.F. DeBano, M.B. Baker, G.J. Gottfried, G. Solis-Garza, C. Edminster, B. Carleton, D.G. Neary, L.S. Allen, and R.H. Hamre, tech. coords., Effects of Fire on Madrean Province Ecosystems - A Symp. Proc., USDA Forest Service, GTR RM-GTR-289, Rocky Mtn. For. & Range Exp. Stn., Ft. Collins, Colorado.

Taylor, L. 1991. Hiker's guide to the Huachuca Mountains. Thunder Peak Productions, Sierra Vista, Arizona. 57pp.

Tellman, B., R. Yarde, and M.G. Wallace. 1997. Arizona's changing rivers: How people have affected the rivers. University of Arizona, Tucson. 198pp.

Trimble, S.W., and A.C. Mendel. 1995. The cow as a geomorphic agent— a critical review. Geomorphology 13:233-253.

U.S. Bureau of Land Management. 1998. The upper San Pedro River Basin of the United States and Mexico, a resource directory and an overview of natural resource issues confronting decision-makers and natural resource managers. Arizona State Office, Report No. BLM/AZ/PT-98/021. 110pp.

U.S. Fish and Wildlife Service (USFWS). 1967. Native fish and wildlife. Endangered species. Federal Register 32(48):4001.

USFWS. 1988. Endangered and threatened wildlife and plants; determination of endangered status for two long-nosed bats. Federal Register 53(190):38456-3860.

USFWS. 1994. Mexican long-nosed bat recovery plan. Albuquerque, New Mexico. 91pp.

USFWS. 1997. Lesser long-nosed bat recovery plan. Albuquerque, New Mexico. 49pp.

U.S. Forest Service (USFS). 1979. Action program for resolution of livestock-riparian conflicts on the Salt River and Verde River: Tonto, Prescott and Coconino National Forests, Region 3. 129pp.

USFS. 1985. Coronado National Forest Plan. Southwestern Region, Albuquerque. 130pp.

USFS. 1998a. Guidance criteria for preliminary effects determinations for species listed as threatened, endangered, or proposed for listing. Region 3, Wildl., Fish, and Rare Plants, Albuquerque, New Mexico. 56pp.

USFS. 1998b. Guidance criteria for determining the effects of issuing term grazing permits on threatened, endangered, or species proposed for listing. Region 3, Albuquerque, New Mexico. 56pp.

USFS. 1998c. Biological assessment of on-going and long term grazing on the Coronado National Forest. Coronado National Forest Supervisor's Office, Tucson, Arizona.

Vallentine, J.F. 1990. Grazing management. Academic Press, San Diego. 533pp.

Van Devender, T.R. 1995. Desert grassland history: Changing climates, evolution, biogeography, and community dynamics. Pages 68-99 in McClaran, M.P., and T.R. Van Devender eds., The Desert Grassland, University of Arizona Press, Tucson.

Van Poolen, H.W., and J.R. Lacey. 1979. Herbage response to grazing systems and stocking intensities. J. of Range Management 32(4):250-253.

Vaughan, T. A. 1976. Nocturnal behaviour of the African false vampire bat *(Cardioderma cor)*. - J. Mammal. 57; 227-24

Villanueva-Diaz, J., and G.R. McPherson. 1995. Effects of climate, fire, land-use history, and structural development on forest communities. Pages 85-98 in Ffolliott, P.F., L.F. DeBano, M.B. Baker, G.J. Gottfried, G. Solis-Garza, C. Edminster, B. Carleton, D.G. Neary, L.S. Allen, and R.H. Hamre, tech. coords., Effects of Fire on Madrean Province Ecosystems - A Symposium Proceedings, USDA Forest Service, General Technical Report RM-GTR-289, Rocky Mtn. For. & Range Exp. Stn., Ft. Collins, Colorado.

Warren, P.L., L.S. Anderson, and P.B. Shaffroth. 1989. Population studies of sensitive plants of the Huachuca and Patagonia Mountains, Arizona. Unpublished Report, Coronado National Forest, Tucson. 99pp.

Warren, P.L. and F.R. Reichenbacher. 1991. Sensitive plant survey of Fort Huachuca, Arizona. Unpublished Report for the US Army, Fort Huachuca, Arizona.

Weltz, M., and M.K. Wood. 1986. Short-duration grazing in central New Mexico: Effects on sediment production. J. of Soil and Water Conservation 41:262-266.

Weltzin, J.F., and G.R. McPherson. 1994. Potential effects of climate change on lower treelines in the southwestern United States. Pages 180-193 in DeBano, L.F., P.F. Ffolliott, A. Ortega-Rubio, G.J. Gottfried, R.H. Hamre, and C.B. Edminster, eds., Biodiversity and Management of the Madrean Archipelago: The Sky Islands of the Southwestern United States and Northwestern Mexico. USDA Forest Service, Gen. Tech. Report RM-GTR-264, Rocky Mtn. For. & Range Exp. Stn., Ft. Collins, Colorado.

Wilcox, B.A., and D.D. Murphy. 1985. Conservation strategy: The effects of fragmentation on extinction. American Naturalist 125:879-887.

Wilkinson, G. S., and T. H. Fleming. 1995. Migration routes and evolution of lesser long-nosed bats, Leptonycteris curasoae, inferred from mitochondrial DNA. Molecular Ecology: in press.

Willard, F.C. 1912. A week afield in southern Arizona. Condor 14:53-63.

Williams, J.E., D.B. Bowman, J.E. Brooks, A.A. Echelle, R.J. Edwards, D.A. Hendrickson, and J.J. Landye. 1985. Endangered aquatic ecosystems in North American deserts, with a list of vanishing fishes of the region. Ariz.-Nev. Acad. Sci. 20:1-12.

Wilson, D.E. 1985. Status report: Leptonycteris sanborni Hoffmeister, Sanborn's long-nosed bat. US Fish and Wildlife Serv., Denver Wildlife Res. Center, Nat'l. Mus. Nat. Hist., Washington D.C. 35pp.

Wright, H.A., and A.W. Bailey. 1982. Fire ecology, United States and Canada. John Wiley and Sons, New York.

York, J.C., and W.A. Dick-Peddie. 1969. Vegetation changes in southern New Mexico during the past hundred years. Pages 157-166 in McGinnies, W.G., and B.J. Goldman, eds., Arid Lands in Perspective, University of Arizona Press, Tucson.

8 Species Profile for the Red-Cockaded Woodpecker

Red-cockaded Woodpecker[1]
Picoides borealis

Status

The red-cockaded woodpecker (RCW) is endangered throughout its range (35 FR 16047, October 13, 1970).

The red-cockaded woodpecker (*Picoides borealis*) is a federally listed endangered species endemic to open, mature, and old growth pine ecosystems in the southeastern United States. Currently, there are an estimated 14,068 red-cockaded woodpeckers living in 5627 known active clusters across 11 states. This is less than 3 percent of estimated abundance at the time of European settlement. Red-cockaded woodpeckers were given federal protection with the passage of the Endangered Species Act in 1973.

Despite this protection, all monitored populations (with one exception) declined in size throughout the 1970's and into the 1980's. In the 1990's, in response to intensive management based on a new understanding of population dynamics and new management tools, most populations were stabilized and many showed increases. Other populations remain in decline, and most have small population sizes. Our major challenge now is to bring about the widespread increases in population sizes necessary for recovery.

Description

The red-cockaded woodpecker is 18 to 20 centimeters long with a wing span of 35 to 38 centimeters. There are black and white horizontal stripes on its back, and its cheeks and underparts are white. Its flanks are black streaked. The cap and stripe on the side of the neck and the throat are

[1] The material in this profile has been derived from numerous sources, and some has been incorporated in various forms with little or no change. It was not possible to annotate every such inclusion fully. Credit must be given to the FWS species profiles, NatureServe summaries, the various RCW recovery plans, and the numerous special and technical reports prepared by researchers at ERDC-CERL over the past 10 years. Especially useful has been the FWS multispecies recovery plan for Florida, which includes several species associated with the longleaf pine system.

black. The male has a small red spot on each side of the black cap. After the first post fledgling molt, fledgling males have a red crown patch. This woodpecker's diet is composed mainly of insects, including ants, beetles, wood-boring insects, caterpillars, and corn ear worms if available. About 16 to 18 percent of the diet includes seasonal wild fruit.

Population

This bird's range is closely tied to the distribution of southern pines. Historically, the red-cockaded woodpecker occurred from east Texas and Oklahoma, to Florida, and north to New Jersey. The present distribution is similar, except the species has been extirpated from Missouri, Tennessee, Maryland, and New Jersey. The former distribution is presented here in Figure 8-1. Populations in Oklahoma, Kentucky, Mississippi, and Virginia are critically low (NatureServe 2006). The remaining populations are fragmented into isolated, island populations, and are considered imperiled by the Nature Conservancy (NatureServe 2003). Current population level is estimated at 4500 groups or 10,000 to 12,000 birds. An active recovery program has been in place since 1990, and a revised recovery plan was issued in 2003 which describes all recognized populations and appropriate recovery goals in some detail (USFWS 2003).

Habitat

Red-cockaded woodpeckers require open pine woodlands and savannahs with large old pines for nesting and roosting habitat (clusters). Large old pines are required as cavity trees because the cavities are excavated completely within inactive heartwood, so that the cavity interior remains free from resin that can entrap the birds. Also, old pines are preferred as cavity trees, because of the higher incidence of the heartwood decay that greatly facilitates cavity excavation. Cavity trees must be in open stands with little or no hardwood midstory and few or no overstory hardwoods. Hardwood encroachment resulting from fire suppression is a well-known cause of cluster abandonment. Red-cockaded woodpeckers also require abundant foraging habitat. Suitable foraging habitat consists of mature pines with an open canopy, low densities of small pines, little or no hardwood or pine midstory, few or no overstory hardwoods, and abundant native bunchgrass and forb groundcovers.

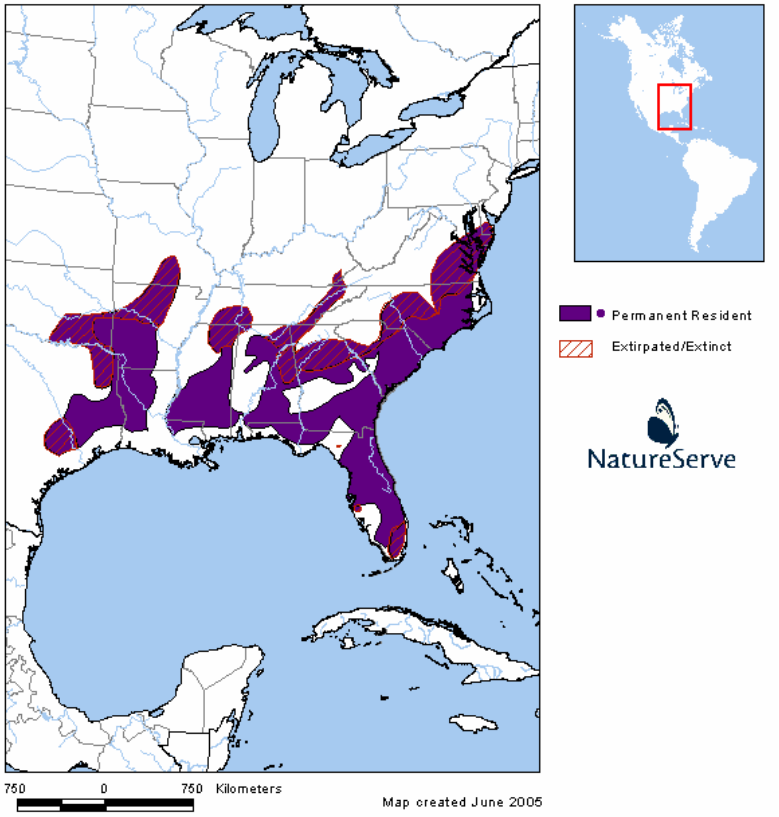

Figure 8-1. RCW distribution map.
(NatureServe 2005).

Open stands of pines with a minimum age of 80 to 120 years, depending on the site, provide suitable nesting habitat. Longleaf pines (*Pinus palustris*) are most commonly used, but numerous other species of southern pine are also acceptable. Nest cavities, and successful colonies, have been found in loblolly (*P. taeda*), shortleaf (*P. echinata*), slash (*P. elliottii*), and Virginia (*P. virginiana*) pines, and occasionally other species, with and without association with longleaf. Foraging habitat is provided in pine and pine hardwood stands 30 years old or older with foraging preference for pine trees 10 inches or larger in diameter. In good, well-stocked, pine habitat, sufficient foraging substrate can be provided on 80 to 125 acres. The main criterion appears to be that the cavity trees must be of adequate size (at least 30 cm in diameter, and preferably larger), and spaced such that the canopy is not continuous. Mixed pine species are tolerated well if these criteria are met, and a mixture of scattered hardwoods often is seen to be accepted so long as they are not allowed to form a continuous, shaded canopy, either upper or mid-story. Dense stands (stands that are

primarily hardwoods, or that have a dense hardwood understory) are avoided.

Roosting cavities are excavated in living pines, and usually in those that are infected with a fungus producing what is known as red-heart disease. The cavity tree ages range from 63 to 300 plus years for longleaf, and 62 to 200 plus years for loblolly and other pines. The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Completed cavities in active use have numerous, small resin wells which exude sap. The birds keep the sap flowing down the bark, apparently as a cavity defense mechanism against rat snakes and possibly other predators. The territory for a group averages about 200 acres, but observers have reported territories running from a low of around 60 acres, to an upper extreme of more than 600 acres. The expanse of territories is related to both habitat suitability and population density.

Threats and Reasons for Current Status

The red-cockaded woodpecker was described by Audubon as being abundant in 1839, but it received little study until around 1970, when investigations began to indicate that the species could be headed for extinction. The decline is attributed primarily to the reduction of pine forest with trees 80 years old and older and to the encroachment of hardwood midstory due to fire suppression in clusters. Living pines in this age group, infected with red-heart disease, generally provide the specialized nesting sites these woodpeckers require.

Nature of the Threat

The RCW is a classic example of a threat solely due to loss of habitat. They were never hunted nor exterminated as pests, as were some other species. In fact, they apparently coexisted with Native Americans, and later European settlers for hundreds of years. It was probably not until roughly the early 20th century that “improved” forest management systems prescribed “cropping” short rotation pines rather than relying on selective removal of some trees while leaving others for “seed trees.” The new, plantation habitat and cropping system simply did not provide either nesting or foraging habitat for the birds. Combined with forest clearing for agriculture, the result has been a series of very small, scattered pockets of remaining habitat for the birds.

Threatened by a loss of habitat (either gradually through poor management or rapidly through the outright destruction of old-growth forests), forest fragmentation, competition with other species for cavities, catastrophic events, and demographic and genetic processes affecting populations confined to isolated conservation areas (USFWS 1985, Ligon et al. 1986, Walters 1991). These threats do not exist independent of one another, and collectively they may render even large populations susceptible to extinction processes over a narrow window of time (Ligon et al. 1986, Walters 1991, Southesst Negotiation Network [SNN] 1990). The dependence of this species on old-growth pine forest is the single most critical factor leading to its endangered status (American Ornithologists' Union [AOU] 1991). This habitat requirement is in direct conflict with timber management policies on some public and almost all private lands (Jackson 1986, Ligon et al. 1986, AOU 1991). Private timber stands in the southeastern United States are generally on short rotations (less than 45 years) that do not permit trees to attain the characteristics sought by red-cockaded woodpeckers (Neel 1971, Ligon et al. 1986, Jackson 1976).

Overall, only 2.5 percent of the current pine acreage in the southeastern United States is considered suitable nesting habitat (USFWS 1985), and most of this exists on public lands, including many military installations of all services. The few stands of old-growth timber remaining on private lands are under increasing pressure to be converted to short-rotation pine plantations (Neel 1971), and legal provisions for maintaining habitat on private lands are weak (Ligon et al. 1986). Management on many public lands focuses on maintenance of "middle-aged" trees rather than old-growth forests (Jackson 1986, Ligon et al. 1986), which again is contrary to the biological requirements of this species. Hovis and Labisky (1985), for example, found that 92 percent of the cavity trees on the Apalachicola National Forest were more than 80 years old, yet more than 50 percent of the pines on this National Forest were less than 60 years old. The consequences of such management can be seen in downward population trends reported for most major populations on public lands (Ligon et al. 1986, AOU 1991, Walters 1991) as well as the potentially unstable conditions reported for some larger populations (James 1991). Since red-cockaded woodpeckers require mature forests and have limited capacities to colonize new areas (Walters 1991), errors in management decisions may take a long time to correct.

A potential decline in the growth of southeastern pine forests (Zeide 1992) could further exacerbate problems on public lands. Hardwood encroachment is also a persistent problem on some public lands owing to the infrequent use of prescribed fires (Hooper et al. 1980, USFWS 1980, Jackson 1986, Ligon et al. 1986, Walters 1991). Hardwood encroachment has been implicated in the decline of numerous populations (Walters 1991). Beckett (1971) and Crosby (1971) were among the first to suggest that red-cockaded woodpeckers abandoned cavity trees and clusters if the hardwood midstory reached the height of the cavity entrance. This has generally been confirmed in work by Thompson and Baker (1971), Carter (1974), Van Balen and Doerr (1978), Wood (1983), and Loeb et al. (1992). It is believed that hardwood trees clustered around cavity trees provide gray rat snakes or flying squirrels, a potential nest predator and a potential nest usurper (Jackson 1974, Jackson 1978b), with access to cavities without having to cross fresh resin (Dennis 1971, Jackson 1974).

Hardwood encroachment may also increase interspecific competition for cavities (Costa and Escano 1989). Finally, hardwood encroachment may also affect the flight path to a cavity (Wood 1983, Kelly et al. 1993) or the quality of foraging habitat (Conner and Rudolph 1991a). Conner and Rudolph (1991b) found that fragmentation and isolation created by forest-harvest patterns also may threaten some populations. Since few large populations exist on lands that are not managed also for timber production fragmentation resulting from timber harvest may threaten many populations. In comparisons of cavities with single males versus cavity clusters with breeders and helpers, Conner and Rudolph (1991b) found the larger groups had fewer clear cuts near cavity sites and less fragmentation of the available foraging habitat (see above). Conner and Rudolph (1991b) warn that it is possible to have a sufficient quantity of foraging habitat within 800 m of an active cluster, but still have insufficient arrangement of foraging habitat. In addition, competition for existing cavities is a pernicious problem and may threaten some small populations (Jackson 1978a, Harlow and Lennartz 1983, Rudolph et al. 1990b, Loeb 1993). Baker (1983) monitored the decline and eventual extirpation of a small red-cockaded woodpecker population in north Florida and found that competition for cavities and aggressive interactions between red-cockaded woodpeckers and other species seemed to increase in frequency and intensity during the decline. The southern flying squirrel, which may occupy 10 to 21 percent of the cavities in some areas (Loeb 1993), is perhaps the most common usurper of red-cockaded cavities (Jackson 1978b, Harlow and

Lennartz 1983, Rudolph et al. 1990a, Loeb 1993), followed by (in approximate order of frequency of use) red-bellied woodpecker, red-headed woodpecker, eastern bluebird, northern flicker, great crested flycatcher (*Myiarchus crinitus*), and tufted titmouse (*Parus bicolor*) (Jackson 1978b, Harlow and Lennartz 1983, Rudolph et al. 1990a). Red-bellied woodpeckers may be the most frequent nest usurpers in some areas (Ligon 1970). Usurpation of cavities by any of these species may be to the detriment of red-cockaded woodpeckers.

Flying squirrels were the major competitor for nest cavities in Texas (Rudolph et al. 1990b) and South Carolina (Loeb 1993), but competition was not thought to be a major factor influencing the stability of the woodpecker population in Texas (Rudolph et al. 1990b). There is little evidence of predation by flying squirrels during the nesting season (Harlow and Doyle 1990). Walters (1991) contended that flying squirrels represent a minor management problem since they do not enlarge the entrance of the cavity. On the other hand, other types of woodpeckers may significantly modify cavities, and once a cavity has been modified, it is rarely used again by red-cockaded woodpeckers (Walters 1991). The pileated woodpecker is particularly destructive since it enlarges a large number of red-cockaded cavities (Jackson 1978a, Walters 1991). There are at least two reasons why cavities enlarged by other woodpeckers are abandoned. Enlarged cavities frequently fill with rain water, and enlarged cavities enable avian and mammalian predators to remove roosting red-cockaded woodpeckers (Jackson 1978). Conner and Rudolph (1995) documented a high rate of southern pine beetle-caused mortality of cavity trees in the Angelina National Forest in Texas. This resulted in a high rate of use of artificial cavities. Trees with cavity inserts may produce less resin and provide less favorable protection against snake predation.

Overall Threats

Limiting factors are those that directly affect the number of potential breeding groups, because this is the primary determinant of population size and trend. Several factors currently impact the persistence of breeding groups. Foremost among these are the factors that limit suitable nesting habitat, namely fire suppression and lack of cavity trees. Fire suppression has resulted in loss of potential breeding groups throughout the range of red-cockaded woodpeckers, because the birds cannot tolerate the hardwood encroachment that results from lack of fire. This limitation is addressed through the use of prescribed burning. Lack of cavity trees, and

potential cavity trees, limits the number of breeding groups in most populations. This limitation is addressed in the short-term through cavity management tools such as artificial cavities and restrictor plates, and over the long-term by growing large old trees in abundance.

Another factor directly limiting the number of potential breeding groups is habitat fragmentation and consequent isolation of groups, which results in disrupted dispersal of helpers and failure to replace breeders. This limitation is best addressed through the appropriate placement of clusters of artificial cavities, and implementation of silvicultural practices that minimize fragmentation.

There are several other threats to the existence and recovery of the species that are not limiting most populations currently, but which will become more important as the current limitations are addressed. Chief among these are (1) degradation of foraging habitat through fire suppression and loss of mature trees, and (2) loss of valuable genetic resources because of small size and isolation of populations. As currently limiting factors such as lack of cavities are relieved, the continued growth and natural stability of red-cockaded woodpecker populations will depend on provision of abundant, good quality foraging habitat and careful conservation of genetic resources.

Catastrophic Events

Hurricanes, epizootic diseases, and, to a lesser extent, beetle infestations, affect populations periodically. The isolated nature of existing populations makes catastrophic events a cause for concern since natural recolonization is unlikely. When Hurricane Hugo passed through South Carolina on September 21-22, 1989, it destroyed almost half of the 100 km^2 of mature forest on the Francis Marion National Forest (Hooper et al. 1990). The storm reduced the population of woodpeckers by a staggering 63 percent, and it destroyed 87 percent of known active cavity clusters (Hooper et al. 1990). Although about 700 birds survived, there were only 225 cavities remaining. The hurricane also destroyed an estimated 50 to 60 percent of the foraging habitat, and it is believed that it may take 75 years for the forest to be suitable habitat for red-cockaded woodpeckers (Hooper et al. 1990, Hamrick 1992). Cavity trees may also be killed by the southern pine beetle (Berlanger et al. 1988, Conner et al. 1991). In Texas, pine beetles killed 53 percent of the 453 cavity trees monitored (Conner et al. 1991).

Fragmentation

The fragmentation and isolation of managed populations within the historic range of the species may threaten to reduce genetic diversity (Ligon et al. 1986) and increase the probabilities of extinction as a result of demographic and environmental fluctuations (Walters 1991). Stangel et al. (1992) found that genetic heterozygosity at 16 presumed gene loci was weakly correlated with population size (smaller populations having less heterozygosity). However, heterozygosity in all populations analyzed fell within "normal" ranges for birds, and this correlation appeared to be heavily influenced by data from two small populations. Ligon et al. (1986) stressed that threats posed by inbreeding and genetic deterioration could extinguish small populations, while Haig et al. (1993) proposed that inbreeding may present a serious threat to the viability of small populations (<20 active clusters). Stangel et al. (1992) also caution against treating small populations as "lost causes" based on the perceived threat of genetic deterioration.

Other Information

Social Structure: Red-cockaded woodpeckers are non-migratory, territorial, and live in cooperative breeding social units called groups. Such groups are typically comprised of a breeding pair and up to three helpers, which are usually males (juvenile females disperse or are expulsed from the breeding groups) and most often offspring of the mated pair from previous years (Jackson 1994). In central Florida, however, the frequency of female helpers is higher than what is reported for populations elsewhere (DeLotelle and Epting 1992). Helpers assist in defending territories (territorial disputes between neighboring groups are common) and in feeding and otherwise caring for the young. Mated pairs usually remain together until one dies, but some inter-group movement of breeding adults occurs (Walters et al. 1988). Breeding groups average 2 to 4 birds prior to breeding and 4 to 6 afterward, but groups numbering up to 8 to 10 birds have been observed. The cooperative breeding social structure of the red-cockaded woodpecker is comparable to the social structure of the Florida scrub-jay (*Aphelocoma coerulescens*), whose breeding groups likewise typically consist of a breeding pair and helpers. The red-cockaded woodpecker and the acorn woodpecker (*Melanerpes formicivorus*), which occur in western North America, are the only cooperatively breeding woodpeckers in North America, but breeding units of the acorn woodpecker commonly have more than one breeding male and/or female.

Cavity Excavation: The red-cockaded woodpecker is the only North American woodpecker that excavates its roost and nest cavities in living trees. Cavities are typically excavated on the west to southwest side of a mature pine tree. They are typically located 10 to 13 m above the ground and are found just below the lowest branches, although cavity height can range from less than 1 m up to almost 100 m (Jackson 1994). Once a cavity is completed, small, conical "resin wells" are excavated above, alongside, and below the cavity, as well as on the opposite side of the tree (Jackson and Thompson 1971). Resin wells are continuously maintained to sustain exudation of sap for the life of the tree. The resulting resin flow gives the tree a glazed, candle-like appearance, which makes it unmistakable as a red-cockaded woodpecker cavity. The resin flow is an effective deterrent to rat snakes (*Elaphe guttata*) and perhaps other predators of cavity-nesting birds (Jackson 1974, Rudolph et al. 1990a). In south-central Florida, in both hydric and mesic habitats, red-cockaded woodpeckers excavate cavities in trees with the crown-bole ratios associated with the maximum resin flow (Bowman and Huh 1995). Red-cockaded woodpeckers also chip away the bark from the immediate vicinity of cavities, creating a smooth plate. Red-cockaded woodpeckers can excavate cavities within a few months, but more typically take 1 to 3 years. It is also possible for a start hole to be created that remains unattended for several months or even years before excavation is resumed; the heartwood may be initially too hard for successful cavity completion, but will soften over time. Cavity trees tend to be aggregated into geographic areas known as clusters (Walters 1990), which support a breeding group. The number of cavity trees in these clusters usually exceeds the size of the breeding group, which allows the breeding group to grow in size and shift its nest locations. Within an active cluster, cavities under construction are called starts, while those that have been completed and are in use are called active (USFWS 1985). It is also typical for a cluster to have a number of trees with start holes and several abandoned cavity trees. Abandoned or inactive trees are often trees that have died (red-cockaded woodpeckers typically abandon cavity trees soon after they die) and/or trees with cavities that have been enlarged or taken over by other species.

Reproduction and Demography: Red-cockaded woodpeckers attain breeding age at 1 year; however, reproductive success improves with increased age (Walters 1990). The nesting season in Florida is late April through early June. The nest cavity is usually the roost cavity of the breeding male (Ligon 1970, Lennartz et al. 1987). The red-cockaded woodpecker

is monogamous, and essentially single-brooded, although rare instances of double-brooding in a given year have been documented (Jackson 1994). Clutch size is normally 2 to 4 eggs (Ligon 1970), and incubation is 10 to 11 days; this is one of the shortest incubation periods among birds (Ligon 1970, Crosby 1971). Both parents and helpers incubate the eggs (Jackson 1994). Usually 1 to 3 young fledge at 26 to 29 days of age (Ligon 1970), but they are dependent to some degree upon their parents and any helpers for 2 to 5 months thereafter (Jackson 1994). Although not all groups produce young, in South Florida, 81 percent of groups were found to be successful. The red-cockaded woodpecker is long-lived for a bird its size; banded birds in the wild have reached 15 years of age, and a captive-reared bird was documented at 13 years (Jackson 1994).

Dispersal: Most female red-cockaded woodpeckers disperse within 1 year after fledging. They may attain breeding status in another territory or become floaters that are not definitively associated with a particular group of birds or cluster of cavity trees (Hovis and Labisky 1985). Some fledgling males also disperse to become breeders or floaters, or to establish and defend a territory, while others remain on their natal territory as helpers until a breeding opportunity arises (Walters et al. 1988). There is little information on dispersal distances for birds in South Florida; however, a dispersal distance of 17 km was reported from Avon Park AFR (P. Ebersbach, Avon Park AFR, personal communication 1996).

Foraging: Red-cockaded woodpeckers forage primarily on arthropods, taken by chipping away the outer layer of tree bark and gleaning what they find underneath. They will occasionally feed on vegetative matter such as pine mast and fruits (Jackson 1994). They have also been observed taking flying insects on the wing. Red-cockaded woodpeckers typically forage in larger pines in pine-dominated habitat (90 percent), rather than in hardwoods (Ramey 1980). Male red-cockaded woodpeckers tend to forage primarily on the branches and upper trunk of pines, whereas females forage primarily on the trunk below the lowest branches (Ligon 1986, Ramey 1980). As stated previously, because of the poor habitat quality in South Florida, more habitat is needed for foraging than in areas farther north (Beever and Dryden 1992).

Reproduction and Development: Egg laying occurs during April, May, and June with the female utilizing her mate's roosting cavity for a nest. Maximum clutch size is seven eggs with the average being three to

five eggs. From egg laying to fledging requires about 38 days, and then another several weeks are needed before the young become completely independent. Most often, the parent birds and some of their male offspring from previous years form a family unit called a group. A group may include one breeding pair and as many as seven other birds. Commonly, these groups are comprised of three to five birds. Rearing the young birds becomes a shared responsibility of the group. However, a single pair can breed successfully without the benefit of the helpers. See section on social behavior, following.

Basic Ecology and Population Dynamics: Red-cockaded woodpeckers are a cooperatively breeding species, living in family groups that typically consist of a breeding pair with or without one or two male helpers. Females may become helpers, but do so at a much lower rate than males. The ecological basis of cooperative breeding in this species is unusually high variation in habitat quality, due to the presence or absence of a critical resource. This critical resource is the cavities that red-cockaded woodpeckers excavate in live pines, a task that commonly takes several years to complete.

Red-cockaded woodpeckers exploit the ability of live pines to produce large amounts of resin, by causing the cavity tree to exude resin through wounds, known as resin wells that the birds keep open. This resin creates an effective barrier against climbing snakes. Longleaf pine is a preferred tree species for cavity excavation because it produces more resin, and for a longer period of time, than other southern pines. Group living has profound influence over population dynamics. In noncooperatively breeding birds, breeders that die are replaced primarily by the young of the previous year. Thus, variation in reproduction and mortality can have strong, immediate impacts on the size of the breeding population. However, in red-cockaded woodpeckers and other cooperative breeders, a large pool of helpers is available to replace breeders. As a result, the size of the breeding population is not strongly affected by how many young are produced each year, or even on how many breeders may die. Because of this, we use the number of potential breeding groups rather than number of individuals as our measure of population size. A potential breeding group is an adult female and adult male that occupy the same cluster, with or without one or more helpers, whether or not they attempt to nest or successfully fledge young. Because of the cooperative breeding system, red-cockaded woodpecker populations are unusually resistant to environmental and demo-

graphic variation, but highly sensitive to the spatial arrangement of habitat. The buffering effect of helpers against annual variation operates only when helpers can readily occupy breeding vacancies as they arise. Helpers do not disperse very far and typically occupy vacancies on their natal territory or a neighboring one. If groups are isolated in space, dispersal of helpers to neighboring territories is disrupted and the buffering effect of the helper class is lost. When this happens, populations become much less likely to persist through time.

Also, the cooperative breeding system does not allow rapid natural growth of populations. Colonization of unoccupied habitat is an exceedingly slow process under natural conditions, because cavities take long periods of time to excavate and birds do not occupy habitat without cavities. As forests age and old pines become abundant, rates of natural cavity excavation and colonization may increase.

Understanding these three components of the population dynamics of red-cockaded woodpeckers provides us the foundation for recovery efforts: (1) population size and trend are determined by the number of potential breeding groups rather than annual variation in reproduction and survival; (2) the buffering capacity of the helper class must be maintained, by maintaining close aggregations of territories; and (3) colonization of unoccupied habitat will be very slow without management assistance.

Army Installations Concerned

The following Army installations reported in the 2000 survey that the red-cockaded woodpecker was found on their property: Camp Blanding, FL; Leesburg Training Site, SC; Fort Bragg, NC; Fort Polk, LA; Fort Stewart, GA; Sunny Point Ocean Terminal, Sunny Point, NC; Fort Benning, GA; Fort Gordon, GA, and Fort Jackson, SC.

The following installations reported that the woodpecker was known to be found on property contiguous with their lands: Camp Beauregard, Pineville, Rapides Parish, LA, and Camp Shelby, Hattiesburg, MS.

Management and Protection

Some of the recommendations included in the species recovery plan are: (1) Survey, monitor, and assess the status of individual populations and the species; (2) Implement protection and management of nesting and

foraging habitat on federal lands; (3) Encourage protection and management on private lands; (4) Conduct research on habitat needs and management, population dynamics, and genetic variation, and (5) Inform and involve the public.

The U.S. Forest Service, the U.S. Fish and Wildlife Service, and the U.S. Army are all working on comprehensive management and recovery guidelines for their respective Federal properties (national forests, national wildlife refuges, and Army installations) where the bird will be recovered. Additionally, the issues surrounding protection and management of red-cockaded woodpeckers on private lands are being addressed through a three-part private lands strategy that includes a procedural manual for private landowners, Statewide Habitat Conservation Plans, and Memorandums of Agreement with industrial forest landowners.

Executive Summary of the RCW Recovery Plan

2nd Revision, January 2003

Actions Needed: The primary actions needed to accomplish the ultimate (delisting) and interim (downlisting) recovery goals are (1) application of frequent fire to both clusters and foraging habitat, (2) protection and development of large, mature pines throughout the landscape, (3) protection of existing cavities and judicious provisioning of artificial cavities, (4) provision of sufficient recruitment clusters in locations chosen to enhance the spatial arrangement of groups, and (5) restoration of sufficient habitat quality and quantity to support the large populations necessary for recovery.

Date of Recovery: We estimate that, with full implementation of this recovery plan, red-cockaded woodpeckers will be downlisted by the year 2050 and delisted by 2075.

Management Protective Measures: When we are speaking of protective measures, the term of reference is that of answering the question of how one must modify normal land management activities. This topic is not identical to managing recovery activities per se, but one of how other ac-

tivities must be redesigned to accommodate the recovering population. If one has a population of woodpeckers under their management, virtually every aspect of forest management will need to be adjusted to meet the guidelines for RCW recovery. Prescribed burning guidance is one of the more complex measures, and is reproduced here, in abbreviated form, from the 2003 Recovery Plan.

Prescribed Burning: Prescribed burning is a part of most modern timber management programs across the southeastern states for timber management purposes alone. A separate version of burning programs is also basic to the management, conservation, and recovery of red-cockaded woodpeckers. In addition, prescribed burning provides benefits for a long list of species associated with southern pine/bunchgrass ecosystems, many of which are themselves rare, threatened, or endangered. Prescribed burning should mimic natural fire regimes as closely as possible, but must be carefully planned and conducted to reduce the likelihood of damage to nesting and foraging habitat. In general, managers are to work toward a prescribed burning program of early to mid-growing season burns on a 1- to 5-year return interval. Habitat with excessive hardwood midstory is to be restored to one with an herbaceous groundcover, preferably by burning at a frequency of 1 to 3 years. Longer intervals are appropriate only for habitat that can be maintained with recommended herbaceous groundcover at those longer burn frequencies. The goal of such a program is to assure that there are numerous small, controllable fires that are limited to the understory, and that fuel does not build to the degree that larger, hot fires are supported, which could burn the resin-soaked cavity trees. This is not a simple problem, and the prescriptions for undertaking such a program are complex.

Understory Control: Prescribed burning is one form of understory control, and the overall goal, of course is to re-create the previous habitat for the bird. It is believed to be the single most important action undertaken by most land managers to promote recovery of the woodpecker. The Florida multispecies recovery plan states it like this: “Red-cockaded woodpeckers will abandon cavity tree clusters when the height of the understory/midstory approaches cavity heights. The most effective method for controlling understory growth is to burn nesting/roosting habitat every 3 to 5 years (Komarek 1977).” Cavity trees, including abandoned trees and trees with start holes, should be afforded some degree of protection during such burns, by manually removing fuel from their vicinity, creating fire

lanes (but not so near cavity trees as to damage root systems), and/or executing burns when climatic conditions would minimize their vulnerability. Existing snags should likewise be afforded the same protection so as to provide nest/roost substrates for other cavity-nesting species that would otherwise compete with red-cockaded woodpeckers. Manual removal of understory and midstory vegetation may be needed in cavity tree clusters or in the immediate vicinity of individual cavity trees when such vegetation is approaching cavity heights and burning has been ineffective in killing it. Foraging habitat should be similarly burned, to reduce fuel that could eventually result in a devastating crown fire, and to promote potential nesting/roosting habitat conditions.

Other Specific Prescriptions: The following actions are the most important of those undertaken specifically to aid recovery, and all go beyond basic land management actions. They are listed in approximate order of value in assistance to recovery, and are abridged from the Florida multispecies recovery plan.

Tree Thinning: Dense stands of young pines (10 to 30 years old) should be thinned to create better foraging habitat. This opens up the habitat and also ensures long-term foraging value by increasing the growth rate of the remaining trees.

Artificial Start Hole Creation: To increase the number of cavities, artificial start holes can be excavated in selected trees both in clusters and in suitable but unoccupied nesting/roosting habitat. Selected trees should be >50 years old and/or >23 cm dbh, and the hole should be situated on the southwesterly side of trees 1 to 3 m below the lower crown branches. Individual holes should be 5.7 cm in diameter and deep enough to penetrate the heartwood. In active clusters, selected trees should be near active cavity trees, and in unoccupied areas selected trees should be grouped into a simulated cluster.

Artificial Cavity Creation: When the availability of trees suitable for cavity excavation in a cluster is severely restricted, or when a management objective is to induce occupation of an unoccupied but suitable area within a short period of time, artificial cavities can be drilled in available trees or constructed cavity boxes (inserts) may be placed into cuts in the boles of larger trees. Both techniques have been demonstrated to be effective in terms of red-cockaded woodpeckers adopting them. However, the cavity

insert technique requires relatively large trees, at least 38 cm in diameter at the height of the planned insert, and the cavity excavation technique requires trees at least 75 years old with 25 cm of heartwood.

Installing Cavity Restrictors: Where competition for cavities from other species is a significant problem, or when rehabilitation of cavities in living trees that have been enlarged by competitors is needed, cavity restrictor devices can be installed on cavities. This technique can significantly reduce cavity competition and/or render previously unsuitable (i.e., enlarged) cavities suitable for occupancy by red-cockaded woodpeckers.

Augmentation: Small, isolated populations are prone to eventual extinction due to stochastic events, demographic problems, and/or a lack of genetic vigor. When the management objective is to maintain such populations, translocations of individual birds can be employed. When isolated populations are extremely small and destined to extirpation, it may be best to translocate the juveniles from those populations, as long as they persist, and introduce them into other, more secure populations.

Military Installation Implications

Fortunately, most normal training activities on installations appear to have only a small potential for conflict with the bird. The most significant implications for military installations appears to be that the forest management activities need to be adjusted, sometimes severely, to accommodate the red-cockaded woodpecker. Most normal Army (or other service) field training does not appear to have significant adverse effects on the birds. Recent studies by ERDC-CERL appear to show that weapons firing, field maneuvers, and use of fog-oil obscurant smoke have no appreciable effect on the RCW (Driver et al. 2003, 2004, 2005).

The most potentially significant military effect appears, from recent experience, to be the need to clear forested areas for use for line of sight and earthmoving associated with range development. Similar clearing for drop zones and helicopter practice landing and bivouac fields could also result in removal of den trees if not well planned. In any case, the Endangered Species Management Plan should flag the need for Section 7 consultations for ANY action affecting mature pine stands as well as other areas that may be required as foraging habitat.

References

References cited in this chapter and selected additional sources for more information.

35 Federal Register (FR) 16047, October 13, 1970

American Ornithologists' Union (AOU), Committee on Classification and Nomenclature. 1983. Check-list of North American Birds. Sixth Edition. American Ornithologists' Union, Allen Press, Inc., Lawrence, Kansas.

AOU Committee for the Conservation of the Red-cockaded Woodpecker. 1991. The conservation crisis. The red-cockaded woodpecker: on the road to oblivion? Auk 108:200-213.

AOU. 1998. Check-list of North American birds. Seventh edition. American Ornithologists' Union, Washington, DC. 829 pp.

Baker, W.W. 1981. The distribution, status and future of the red-cockaded woodpecker in Georgia. pp. 82- 87 In R.R. Odom and J.W. Guthrie, (eds.) Proc. Nongame and Endangered Wildl. Symp., Ga. Dept. Nat. Res. Game & Fish Div., Tech. Bull. WL5.

Baker, W. W. 1983. Decline and extirpation of a population of red-cockaded woodpeckers in northwest Florida. Pages 44-45 in D. A. Wood, editor. Red-cockaded woodpecker symposium II proceedings. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Baker, W.W. 1995. The distribution and status of the red-cockaded woodpecker (Picoides borealis) in Georgia, 1992. pp. 465-469 In Kulhavey, D.L., R.G. Hooper, and R. Costa, (eds.) Red-cockaded woodpecker: recovery, ecology and management. Center for Appl. Studies in Forestry, College of Forestry, Stephen F. Austin State Univ., Nacogdoches, TX.

Baker, W.W. and J.W. Thompson. 1989. Status of the red-cockaded woodpecker in Georgia. Final report to the Georgia Department of Natural Resources. 9 pp.

Balbach, Harold, Patricia M. Kirby (Editors). 2001. Red-cockaded Woodpecker Research at ERDC/CERL , Report Number ERDC/CERL SR-01-3.

Beckett, T. A., III. 1971. A summary of red-cockaded woodpecker observations in South Carolina. Pages 87-95 *in* R. L. Thompson, editor. The ecology and management of the red-cockaded woodpecker. Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, and Tall Timbers Research Station, Tallahassee, Florida, USA.

Beever, J. W., and K. A. Dryden. 1992. Red-cockaded woodpeckers and hydric slash pine flatwoods. Transactions of the North American Wildlife and Natural Resources Conference 57:693-700.

Belanger, R. P., R. L. Hedden, and M. R. Lennartz. 1988. Potential impact of the southern pine beetle on red-cockaded woodpecker colonies in the Georgia Piedmont. Southern Journal of Applied Forestry 12:194-199.

Bent, A.C. 1942. Life histories of North American flycatchers, larks, swallows, and their allies. U.S. National Museum Bulletin 179. Washington, DC.

Bowman, R., and C. Huh. 1995. Tree characteristics, resin flow, and heartwood rot in Pines (*Pinus palustris, Pinus elliottii*), with respect to red-cockaded woodpecker cavity excavation, in two hydrologically-distinct Florida flatwood communities. Pages 415-426 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology and management. Center for Applied Studies in Forestry, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas, USA.

Burleigh, T.D. 1958. Georgia Birds. Univ. of Oklahoma Press, Norman. 746 pp.

Chapman, F.M. 1900. Handbook of birds of eastern North America. D. Appleton and Co., NY 431 pp.

Byrd, M. A., and D. W. Johnston. 1991. Birds. Pages 477-537 in K. Terwilliger, coordinator. Virginia's endangered species: proceedings of a symposium. McDonald and Woodward Publ. Co., Blacksburg, Virginia.

Campbell, L. 1995. Endangered and Threatened Animals of Texas: Their Life History and Management. Texas Parks and Wildlife Department, Endangered Resources Branch, Austin, Texas. ix + 129 pp.

Carter, J. H., III. 1974. Habitat utilization and population status of the red-cockaded woodpecker in south-central North Carolina. Thesis, North Carolina State University, Raleigh, North Carolina, USA.

Carter, J. H., III, et al. 1989. Restrictors for red-cockaded woodpecker cavities. Wildlife Society Bull. 17:68-72.

Collar, N.J., L.P. Gonzaga, N. Krabbe, A. Madrono-Nieto, L.G. Naranjo, T.A. Parker III, and D.C. Wege. 1992. Threatened Birds of the Americas. The ICBP/IUCN Red Data Book. Third Edition. Part 2. Smithsonian Institution Press, Washington, DC. 1150 pp.

Conner, R. N., A. E. Snow, and K. A. O'Halloran. 1991. Red-cockaded woodpecker use of seed-tree/shelterwood cuts in eastern Texas. Wildl. Soc. Bull. 19:67-73.

Conner, R. N., and D. C. Rudolph. 1989. Red-cockaded woodpecker colony status and trends on the Angelina, Davy Crockett and Sabine national forests (east. Texas). U. S. Forest Service Research Paper S)-250. 15 pp.

Conner, R. N., and D. C. Rudolph. 1991a. Effects of midstory reduction and thinning in red-cockaded woodpecker cavity tree clusters. Wildl. Soc. Bull. 19:63-66.

Conner, R. N., and D. C. Rudolph. 1991b. Forest habitat loss, fragmentation, and red-cockaded woodpecker populations. Wilson Bull. 103:446-457.

Conner, R. N., and D. C. Rudolph. 1995. Losses of red-cockaded woodpecker cavity trees to southern pine beetles. Wilson Bulletin 107:81-92.

Conner, R. N., et al. 1991. Causes of mortality of red-cockaded woodpecker cavity trees. J. Wildlife Management 55:531-537.

Copeyon, C. K. 1990. A technique for constructing cavities for the red-cockaded woodpecker. Wildl. Soc. Bull. 18:303-311.

Copeyon, C. K., J. R. Walters, and J. H. Carter, III. 1991. Induction of red-cockaded woodpecker group formation by artificial cavity construction. J. Wildlife Management 55:549-556.

Costa, R. 1995. Red-cockaded woodpecker recovery and private lands: a conservation strategy responsive to the issues. pp. 67-74 In Kulhavey, D.L., R.G. Hooper, and R. Costa, (eds.) Red-cockaded woodpecker: recovery, ecology and management. Center for Appl. Studies in Forestry, College of Forestry, Stephen F. Austin State Univ., Nacogdoches, TX.

Costa, R., and R. Escano. 1989. Red-cockaded woodpecker: status and management in the southern region in 1986. U.S. Forest Service Technical Publication R8-TP12.

Crosby, G. T. 1971. Home range characteristics of the red-cockaded woodpecker in north-central Florida. Pages 60-73 *in* R. L. Thompson, editor. The ecology and management of the red-cockaded woodpecker. Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, and Tall Timbers Research Station, Tallahassee, Florida, USA.

Crowder, L.B., J.A. Priddy, and J.R. Walters. 1998. Demographic isolation of red-cockaded woodpecker groups: a model analysis. Project final report. Duke Univ., Nicholas School of the Environment, Beaufort, NC. 17pp.

Delaney, David K. , Larry L. Pater, Robert J. Dooling, Bernard Lohr, Beth F. Brittan-Powell, Linton L. Swindell, Tim A. Beaty, Larry D. Carlile, Eric W. Spadgenske, Bruce A. MacAllister, and Robert H. Melton. 2002. Assessment of Training Noise Impacts on the Red-Cockaded Woodpecker: 1998 – 2000. ERDC/CERL TR-02-32

DeLotelle, R. S., and R. J. Epting. 1992. Reproduction of the red-cockaded woodpecker in central Florida. Wilson Bull. 104:285-294.

Department of Defense. 1991. Proceedings of the Department of Defense red-cockaded woodpecker workshop, Marine Corps Base Camp Lejeune, North Carolina, 3-5 April 1991. 123 pp.

Driver, Crystal, Michael Ligotke, Heather Galloway-Gorby, Gary Dennis, Keturah Reinbold, and Harold Balbach. 2002. Acute Inhalation Toxicity of Fog Oil Smoke in the Red-winged Blackbird, a Size-specific Inhalation Surrogate for the Red-cockaded Woodpecker ,Report Number ERDC/CERL TR-02-6.

Driver, Crystal, Jennifer Ollero, Yin Fong Su, Robert Fulton, Gary Dennis, Brett Tiller, Harold Balbach, and Keturah Reinbold. 2003. Effects of Fog Oil Smoke on the Hatchability and Fledgling Survival of the House Sparrow (Passer domesticus), a Nestling Surrogate for the Red-cockaded Woodpecker ,Report Number ERDC/CERL TR-02-34.

Driver, C., A. Jarrell, J. Ollero, B. Tiller, R. Fulton, G. Dennis, H. Balbach, and K. Reinbold. 2004. Effects of Fog Oil Smoke on Immune Responses in the House Sparrow (Passer domesticus) and Red-winged Blackbird (Agelaius phoeniceus) USA CERL, Champaign, IL, Report Number ERDC/CERL TR-04-13.

Driver, C., R. Fulton, J. Ollero, M. Clark, G. Dennis, B. Tiller, and H. Balbach, 2005. Inhalation Toxicity of Cogenerated Graphite Flake and Fog Oil Smoke in the Brown-headed Cowbird and the Red-winged Blackbird, Size-specific Inhalation Surrogates for the Red-cockaded Woodpecker. USA CERL, Champaign, IL, Report Number ERDC/CERL TR-05-5.

Eddleman, W. R., and R. L. Clawson. 1987. Population status and habitat conditions for the red-cockaded woodpecker in Missouri. Trans. Missouri Acad. Sci. 21:105-117.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1992. Birds in Jeopardy: the Imperiled and Extinct Birds of the United States and Canada, Including Hawaii and Puerto Rico. Stanford University Press, Stanford, California. 259 pp.

Engstrom, R. T., and G. W. Evans. 1990. Hurricane damage to red-cockaded woodpecker (PICOIDES BOREALIS) cavity trees. Auk 107:608-610.

Florida Fish and Wildlife Conservation Commission. 2001. Preliminary biological status report, Red-cockaded Woodpecker (PICOIDES BOREALIS). Florida Fish and Wildlife Conservation Commission, unpublished report available at: at: http://www.nettally.com/necox/rcw/rcwbas.htm.

Florida Ornithological Society. 2001. Report of the Conservation Committee of the Florida Ornithological Society on the proposed change in status of the Red-cockaded Woodpecker in Florida. Unpublished report available at: http://www.nettally.com/necox/rcw/index.html. Accessed 2001-10-22.

Greene, E.R., W.W. Griffin, E.P. Odum, H.L. Stoddard, and I.R. Tompkins. 1945. Birds of Georgia. Univ. Georgia Press, Athens

Hagan, J. M., and J. M. Reed. 1988. Red color bands reduce fledging success in red-cockaded woodpecker. Auk 105:498-503.

Haig, S. M., J. R. Belthoff, and D. H. Allen. 1993. Examination of population structure in red-cockaded woodpeckers using DNA profiles. Evolution 47:185-194.

Hamrick, D. 1992. Assisting homeless woodpeckers: red-cockaded woodpeckers affected by hurricane Hugo. Birds International 3:18-27.

Hanula, J. L., and K. E. Franzreb. 1995. Arthropod prey of nestling red-cockaded woodpeckers in the upper Coastal Plain of South Carolina. Wilson Bulletin 107:485-495.

Harlow, R. F., and A. T. Doyle. 1990. Food habits of southern flying squirrels (Glaucomys volans) collected from red-cockaded woodpecker (Picoides borealis) colonies in South Carolina. American Midland Naturalist 124:187-191.

Harlow, R. F., and M. R. Lennartz. 1983. Interspecific competition for red-cockaded woodpecker cavities during the breeding season in South Carolina. Pages 41-43 *in* D. A. Wood, editor. Red-cockaded woodpecker symposium II proceedings. Florida Game and Fresh Water Fish Commission , Tallahassee, Florida, USA.

Harrison, C. 1978. A Field Guide to the Nests, Eggs and Nestlings of North American Birds. Collins, Cleveland, Ohio.

Harrison, H. H. 1979. A field guide to western birds' nests. Houghton Mifflin Company, Boston. 279 pp.

Hayden, Timothy J. , Robert H. Melton, Beth Willis, L.B. Martin III, and Tim Beaty. 2002, Assessment of Effects of Maneuver Training Activities on Red-cockaded Woodpecker Populations on Fort Stewart, GA. ERDC/CERL TR-02-17

Hooper, R. G. 1988. Longleaf pines used for cavities by red-cockaded woodpeckers. J. Wildlife Management 52:392-398.

Hooper, R. G., D. L. Krusac, and D. L. Carlson. 1991. An increase in a population of red-cockaded woodpeckers. Wildlife Society Bull. 19:277-286.

Hooper, R. G., J. Watson, and R. E. Escano. 1990. Hurricane Hugo's initial effects on Red-cockaded Woodpeckers in the Francis Marion National Forest. Transactions of the North American Wildlife and Natural Resources Conference 55:220-224.

Hooper, R. G., M. R. Lennartz, and H. D. Muse. 1991. Heart rot and cavity tree selection by red-cockaded woodpeckers. J. Wildlife Management 55:323-327.

Hooper, R. G., and C. J. McAdie. 1995. Hurricanes and long-term management of the Red-cockaded Woodpecker. Pages 167-171 in D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded Woodpecker: recovery, ecology, and management. Center for Applied Studies, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Hooper, R. G., A. F. Robinson, Jr., and J. A. Jackson. 1980. The red-cockaded woodpecker: notes on life history and management. U.S. Forest Service, Southern Region General Report SA-GR 9.

Hooper, R. G., and H. D. Muse. 1989. Sequentially observed periodic surveys of management compartments to monitor red-cockaded woodpeckers. U.S. Forest Service Research Paper SE-276. 13 pp.

Hovis, JA, and R. F Labisky. 1985. Vegetative associations of Red-cockaded Woodpecker colonies in Florida. Wildlife Society Bulletin 13:307-314.

Jackson, J. A. 1974. Gray rat snakes versus red-cockaded woodpeckers: predator-prey adaptations. Auk 91:342-347.

Jackson, J. A. 1976. Rights-of-way management for an endangered species: the red-cockaded woodpecker. Pages 247-252 *in* R. Tillman, editor. Proceedings of the first national symposium on environmental concerns in rights-of-way management. Mississippi State University, Mississippi State, Mississippi, USA.

Jackson, J. A. 1978a. Analysis of the distribution and population status of the red-cockaded woodpecker. Pages 101-111 *in* R. R. Odum, and L. Landers, editors. Proceedings of the rare and endangered wildlife symposium. Georgia Department of Natural Resources, Game and Fish Division Technical Bulletin W44.

Jackson, J. A. 1978b. Competition for cavities and red-cockaded woodpecker management. Pages 103-112 *in* S. A. Temple, editor. Endangered birds: management techniques for the preservation of threatened species. University Wisconsin Press, Madison, Wisconsin, USA.

Jackson, J. A. 1986. Biopolitics, management of federal lands, and the conservation of the red-cockaded woodpecker. American Birds 40:1162-1168.

Jackson, J. A. 1990. Intercolony movements of red-cockaded woodpeckers in South Carolina. J. Field Ornithology 61:149-155.

Jackson, J.A. 1994. Red-cockaded woodpecker (Picoides borealis). in A. Poole and F. Gill, eds. The birds of North America, No. 85. The Academy of Natural Sciences; Washington, D.C., The American Ornithologists. Union; Philadelphia, Pennsylvania.

Jackson, J. A., and R. L. Thompson. 1971. A glossary of terms used in association with the red-cockaded woodpecker. Pages 187-188 in R. L. Thompson, editor. The ecology and management of the red-cockaded woodpecker. Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, and Tall Timbers Research Station, Tallahassee, Florida, USA.

James, F. C. 1991. Signs of trouble in the largest remaining population of red-cockaded woodpeckers. Auk 108:419-423.

James, F. C. 1995. Status of the Red-cockaded Woodpecker in 1990 and prospect for recovery. Pages 439-451 IN D. Kulhavy, R. G. Hooper, and R. Costa (editors). Red-cockaded Woodpecker: recovery, ecology, and management. Stephen F. Austin State University, Nacogdoches, Texas.

Kalisz, P. J., and S. E. Boettcher. 1991. Active and abandoned red-cockaded woodpecker habitat in Kentucky. J. Wildlife Management 55:146-154.

Kelly, J. F., S. M. Pletschet, and D. M. Leslie, Jr. 1994. Decline of the red-cockaded woodpecker (Picoides borealis) in southeastern Oklahoma. American Midland Naturalist 132:275-283.

Kelly, J. F., S. M. Pletschet, and D. M. Leslie, Jr. 1993. Habitat associations of red-cockaded woodpecker cavity trees in an old-growth forest of Oklahoma. Journal of Wildlife Management 57:122-128.

Komarek, E. V. 1977. Red-cockaded woodpecker studies. Pages 60-61 in Tall Timbers Research Station: a quest for ecological understanding. Tall Timbers Research Station, Tallahassee, Florida, USA.

LaBranche, M. S., J. R. Walters, and K. S. Laves. 1994. Double-brooding in red-cockaded woodpeckers. Wilson Bull. 106:403-408.

LaBranche, M. S., and J. R. Walters. 1994. Patterns of mortality in nests of red-cockaded woodpeckers in the sandhills of south central North Carolina. Wilson Bull. 106:258-271.

Lennartz, M. R. 1988. The red-cockaded woodpecker: old-growth species in a second-growth landscape. Natural Areas J. 8:160-165.

Lennartz, M. R., and V. G. Henry. 1985. Red-cockaded woodpecker recovery plan (revision). U.S. Fish and Wildlife Service. 92 pp.

Lennartz, M. R., and J. D. Metteauer. 1987. Test of a population estimation technique for red-cockaded woodpeckers. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 40:320-324.

Letcher, B.H., J.A. Priddy, J. R. Walters, and L.B. Crowder. 1998. An individual-based spatially- explicit simulation model of the population dynamics of the endangered red-cockaded woodpecker, Picoides borealis. Biol. Conserv.

Ligon, J. D. 1970. Behavior and breeding biology of the red-cockaded woodpecker. Auk 87:255-278.

Ligon, J. D., et al. 1986. Report of the American Ornithologists' Union Committee for the Conservation of the Red-cockaded Woodpecker. Auk 103:848-855.

Loeb, S. C. 1993. Use and selection of red-cockaded woodpecker cavities by southern flying squirrels. Journal of Wildlife Management 57:329-335.

Loeb, S. C., W. D. Pepper, and A. T. Doyle. 1992. Habitat characteristics of active and abandoned red-cockaded woodpecker colonies. Southern Journal of Applied Forestry 16:120-125.

Marion, W. R., and B. W. Hagedorn, compilers. 1991. A literature reference guide for the red-cockaded woodpecker. Department of Defense Legacy Resource Management Program. 105 pp.

Masters, R. E., J. E. Skeen, and J. A. Garner. 1989. Red-cockaded woodpecker in Oklahoma: an update of Wood's 1974-1977 study. Proceedings Oklahoma Academy Science 69:27-31.

Matthews, J. R., and C. J. Moseley (editors). 1990. The Official World Wildlife Fund Guide to Endangered Species of North America. Volume 1. Plants, Mammals. xxiii + pp 1-560 + 33 pp. appendix + 6 pp. glossary + 16 pp. index. Volume 2. Birds, Reptiles, Amphibians, Fishes, Mussels, Crustaceans, Snails, Insects, and Arachnids. xiii + pp. 561-1180. Beacham Publications, Inc., Washington, D.C.

McFarlane, R. W. 1992. A stillness in the pines: the ecology of the red-cockaded woodpecker. W. W. Norton and Company, New York. 270 pp.

Mengel, R. M., and J. A. Jackson. 1977. Geographic variation of the red-cockaded woodpecker. Condor 79:349-355.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 16, 2006).

Neel, L. 1971. Some observations on the red-cockaded woodpecker in the Thomasville-Tallahassee game preserve region. Pages 137-139 *in* R. L. Thompson, editor. The ecology and management of the red-cockaded woodpecker. Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, and Tall Timbers Research Station, Tallahassee, Florida, USA.

Neal, J. C., et al. 1993. Effects of weather and helpers on survival of nestling red-cockaded woodpeckers. Wilson Bull. 105:666-673.

Ortego, B., and D. Lay. 1988. Status of red-cockaded woodpecker colonies on private land in east Texas. Wildlife Society Bull. 16:403-405.

Porter, M. L., and R. F. Labisky. 1986. Home range and foraging habitat of red-cockaded woodpeckers in northern Florida. J. Wildlife Management 50:239-247.

Ramey, P. 1980. Seasonal, sexual, and geographical variation in the foraging ecology of the red-cockaded woodpecker (*Picoides borealis*). Thesis, Mississippi State University, Mississippi State, Mississippi, USA.

Reed, J. M., P. D. Doerr, and J. R. Walters. 1988. Minimum viable population size of the red-cockaded woodpecker. J. Wildlife Management 52:385-391.

Reed, J. M., et al. 1993. Effective population size in red-cockaded woodpeckers: population and model differences. Conservation Biology 7:302-

Reeds, J. M., et al. 1988. An evaluation of indices of red-cockaded woodpecker populations. Wildlife Society Bull. 16:4-6-410.

Reparsky, R. R., and P. D. Doerr. 1991. Home range and substrate use by two family groups of red-cockaded woodpeckers in the North Carolina sandhills. Brimleyana 17:37-52.

Repasky, R. R., R. J. Blue, and P. D. Doerr. 1991. Laying red-cockaded woodpeckers cache bone fragments. Condor 93:458-461.

Roise, J., et al. 1990. Red-cockaded woodpecker habitat and timber management: production possibilities. South. J. Appl. For. 14:6-12.

Rossell, C. R., Jr., and J. J. Britcher. 1994. Evidence of plural breeding by red-cockaded woodpeckers. Wilson Bull. 106:557-559.

Rudloph, D. H., H. Kyle, and R. N. Conner. 1990a. Red-cockaded woodpeckers vs. rat snakes: the effectiveness of the resin barrier. Wilson Bull. 102:14-22.

Rudolph, D. C., R. N. Conner, and J. Turner. 1990b. Competition for red-cockaded woodpecker roost and nest cavities: effects of resin age and entrance diameter. Wilson Bull. 102:23-36.

Rudolph, D. C., and R. N. Conner. 1991. Cavity tree selection by red-cockaded woodpeckers in relation to tree age. Wilson Bull. 103:458-467.

Rudolph, D. C., et al. 1992. Experimental reintroduction of red-cockaded woodpeckers. Auk 109:914-916.

Short, L. L. 1982. Woodpeckers of the World. Museum of Natural History [Greenville, Delaware], Monograph Series xviii + 676 pp.

Southeast Negotiation Network (SNN), Georgia Inst. of Technology, Atlanta. 1990. Summary report: scientific summit on the red-cockaded woodpecker.

Stangel, P. W., M. R. Lennartz, and M. H. Smith. 1992. Genetic variation and population structure of red-cockaded woodpeckers. Conservation Biology 6:283-292.

Stevens, E. E. 1992. Population dynamics of red-cockaded woodpeckers in the Georgia Piedmont. Abstract, 6th Annual Meeting of the Society for Conservation Biology, p. 120.

Terres, J. K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York.

Thomlinson, J. R. 1995. Landscape characteristics associated with active and abandoned red-cockaded woodpecker clusters in east Texas. Wilson Bulletin 107:603-614.

Thompson, R.L., ed. 1971. The ecology and management of the red-cockaded woodpecker. USDI, Bureau of Fisheries and Wildlife, and Tall Timbers Research Station. 188 pp.

Thompson, R. L., and W. W. Baker. 1971. A survey of red-cockaded woodpecker habitat requirements. Pages 170-188 *in* R. L. Thompson, editor. The ecology and management of the red-cockaded woodpecker. Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, and Tall Timbers Research Station, Tallahassee, Florida, USA.

U.S. Fish and Wildlife Service. 1980. Selected vertebrate endangered species of the seacoast of the United Sates-- the red-cockaded woodpecker. FWS/OBS-80/01.7. 9 pp.

U.S. Fish and Wildlife Service. 1985. Recovery Plan for the Red-cockaded Woodpecker. U.S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia. 88 pages.

U.S. Fish and Wildlife Service. 19 October 1989. Remarkable survival of endangered species reported; hurricane's impact on habitat extensive. News Release.

U.S. Fish and Wildlife Service (USFWS). 1990. Endangered and threatened species recovery program: report to Congress. 406 pp.

U.S. Fish and Wildlife Service. 2000. Technical/agency draft revised recovery plan for the Red-cockaded Woodpecker (PICOIDES BOREALIS). U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 2003. Recovery plan for the red-cockaded woodpecker (Picoides borealis): second revision. U.S. Fish and Wildlife Service, Atlanta, GA. 296 pp.

Van Balen, J. B., and P. D. Doerr. 1978. The relationship of understory vegetation to red-cockaded woodpecker activity. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 32:82-92.

Walters, J. R. 1990. The red-cockaded woodpecker: a "primitive cooperative breeder." In P. B. Stacey and W. D. Koenig, eds. Cooperative breeding in birds: long-term studies of ecology and behavior. Cambridge Univ. Press.

Walters, J. R. 1991. Application of ecological principles to the management of endangered species: the case of the red-cockaded woodpecker. Annual Rev. Ecol. Syst. 22:505-523.

Walters, J. R., C. K. Copeyon, and J. H. Carter, III. 1992. Test of the ecological basis of cooperative breeding in red-cockaded woodpeckers. Auk 109:90-97.

Walters, J. R., P. D. Doerr, and J. H. Carter, III. 1988. The cooperative breeding system of the red-cockaded woodpecker. Ethology 78:275-305.

Wood, D. A., editor. 1983. Red-cockaded woodpecker symposium II proceedings. Florida Game and Fresh Water Fish Commission. 112 pp.

Zeide, B. 1992. Has pine growth declined in the southeastern United States? Conservation Biology 6:185-195.

9 Recommendations

The material contained here is intended to be utilized primarily by research, land management, and training directorate personnel who are not trained biologists, or, at least, are not trained with respect to one or more of the species included. The suggested uses include general orientation as to the characteristics and needs of the various species, and awareness of the nature of the potential for Army involvement with them. While the information presented here is from reliable sources, all references to it in subsequent reports and publications should be considered secondary, and the original sources should be cited where appropriate. A lengthy list of publications and sources has been included at the end of each chapter. Many of these were used in the assembly of this guidance, while many more are recommended as original sources for references to be examined in the preparation of biological assessments and NEPA documentation. The material may also be provided to contractors who are new to the location or have not worked in the habitats previously. The mitigation recommendations in each chapter may also be used to contribute to the development of management plans for various construction and operation activities.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
11-2007	Final	

4. TITLE AND SUBTITLE
Profiles for High-Priority Species
Focus of the Army Threatened and Endangered Species Research Program

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Harold E. Balbach and Elizabeth L. Keane

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
008B36

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
PO Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CERL TR-07-48

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.A. Army Corps of Engineers
Office of the Director of Environmental Programs
NC1 Presidential Towers, Suite 9300
2511 Jefferson Davis Highway
Arlington, VA 22202Alexandria, VA

10. SPONSOR/MONITOR'S ACRONYM(S)
DAIM

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

14. ABSTRACT

A need arose during the conduct of Threatened and Endangered Species (TES) research for a source of material about the Army's priority TES that would be accessible to (primarily) non-biologist researchers performing various studies on habitat associations using remote sensing, GIS, and other technologies. This is a primer to the characteristics of the species, and why they were of interest to the Army; it also identifies in a preliminary way where the critical gaps were in our knowledge about the TES. This material is intended to be used primarily by research, land man-agement, and training directorate personnel who are not trained biologists, or are not trained with respect to one or more of the species in-cluded. The suggested uses include general orientation as to the characteristics and needs of the various species, and awareness of the nature of the potential for Army involvement with them. Although the information presented here is from reliable sources, all references to this document in subsequent reports and publications should be considered secondary, and the original sources should be cited where appropriate. The material may also be provided to contractors who are new to the location or have not worked in the habitats previously.

15. SUBJECT TERMS
Threatened and Endangered Species (TES) | ecological systems | high priority species
environmental management | species checklist | wildlife management

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Harold E. Balbach
Unclassified	Unclassified	Unclassified	SAR	186	19b. TELEPHONE NUMBER (include area code) (217) 352-6511, ext 6785